Stock Repurchases and Market Liquidity

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Abstract

We analyze the relationship between share repurchases and liquidity based on a newly available data set of realized share repurchases in the US, which covers 50,112 repurchase months of 2,942 firms between 2004 and 2010. We formulate hypotheses based on the presumption that firms operate in limit order markets and either demand liquidity by posting market orders or supply liquidity by posting limit orders. The *repurchase-intensity hypothesis* postulates that firms consume liquidity with smaller repurchases and supply liquidity with larger repurchases. The *gravitational-pull hypothesis* of Cohen, Maier, Schwartz, and Whitcomb (JPE 1981) predicts that firms supply liquidity if the market is illiquid and consume liquidity if the market is liquid. Our evidence supports both hypotheses. On average, repurchases generate additional liquidity, but this relationship displays significant cross-sectional variation and restricting the sample to larger firms generates the opposite result. The stock performance after repurchases reveals that information-based repurchases do not consume liquidity.

Keywords: Share repurchases, market microstructure, liquidity, limit order markets

JEL classifications: G10, G30, G35

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1 Introduction

A literature in financial economics dating back at least to Amihud and Mendelson (1986) demonstrates a consistent and economically significant relationship between firms' cost of capital and the liquidity of their stock.[1] If managers wish to maximize firm value, they should therefore pursue financial policies that improve the liquidity of their stock and thereby reduce their cost of capital. Among firms' financial policies that may affect stock market liquidity, share repurchases have attracted most attention by researchers. Following Barclay and Smith (1988), several authors have analyzed the impact of repurchases on stock liquidity and found that repurchases reduce rather than enhance liquidity in France and Hong Kong, whereas the impact is positive in Sweden, Switzerland, and Italy.[2] The evidence for the US is ambiguous and hampered by the fact that data on realized share repurchases have become available only recently.[3] Hence, despite the importance and the considerable interest in the subject, no coherent picture of the relationship between repurchases and liquidity has emerged.

In this paper, we provide a fresh look at this subject by reformulating the underlying theory, refining the methodology, and by relying on a unique and much more comprehensive data set compared to previous research. Barclay and Smith (1988) formulate two hypotheses on the relationship between repurchases and liquidity. The *information-asymmetry hypothesis* postulates that firms have privileged information so that repurchases are akin to insider purchases. The model of Barclay and Smith (1988) extends Glosten and Milgrom (1985) and shows how more precise information by informed insiders and a higher proportion of

[1] Amihud and Mendelson (1986), Barclay and Smith (1988), and Acharya and Pedersen (2005) provide theoretical models that predict a positive relationship between the cost of capital and the bid-ask spread. Empirical work by Brennan and Subrahmanyam (1996), Easley, Hvidkjaer, and O'Hara (2002), Amihud (2002), Pastor and Stambaugh (2003), Bekaert, Harvey, and Lundblad (2007), Hasbrouck (2009), Duarte and Young (2009), and Lee (2011) provides support for this prediction.

[2] See Ginglinger and Hamon (2007) for France, Brockman and Chung (2001) for Hong Kong, De Cesari, Espenlaub, and Khurshed (2011) for Italy, Rasbrant and De Ridder (2011) for Sweden, and Chung, Isakov, and Perignon (2007) for Switzerland.

[3] Barclay and Smith (1988) look at repurchase announcements and found a negative impact for the US. Cook, Krigman, and Leach (2004) provide univariate analysis of a small, hand-collected sample and find a positive effect. Nayar, Singh, and Zebedee (2008) analyze fixed price tender offers and dutch auctions and Oded, Ben-Rephael, and Wohl (2011) study recently disclosed, realized repurchases. The latter two studies both find positive effects.

informed traders in the market increases the bid-ask spread and therefore reduces liquidity. By contrast, the *competing market-maker hypothesis* builds on the notion that firms purchase shares as a form of disbursing cash to shareholders and act as a market maker in their own stock who supplies liquidity. The two hypotheses have diametrically opposite implications, but they are not mutually exclusive and may apply to different firms, or even to different time periods of the same firm. The empirical literature on the link between liquidity and repurchases has analyzed the impact of repurchases on spreads based on this conceptual framework.

Our analysis is based on the notion that modern exchanges are organized as limit order markets. Recent research on limit order markets suggests that equating informed trading with liquidity demand and non-information based liquidity trading with liquidity supply may be unwarranted.[4] Kaniel and Liu (2006) extend earlier models by allowing for informed limit orders and conclude that limit orders may be optimal for informed traders if private information is sufficiently long-lived. Goettler, Parlour, and Rajan (2009) develop a dynamic model of a limit-order market with heterogeneous investors and show that investors with the highest inclination to become informed ("speculators") use limit orders.[5] Bloomfield, O'Hara, and Saar (2005) study an experimental setting and find that informed traders may use limit orders more than liquidity traders. Empirical work concurs with these views. Anand, Chakravarty, and Martell (2005) show that informed (institutional) traders use limit orders that perform better than those of uninformed traders and the empirical results of Kaniel and Liu (2006) also indicate that informed traders use limit orders.

In view of these developments in microstructure research, the hypotheses of Barclay and Smith (1988) need to be revised and extended, at least with respect to open-market repur-

[4]See Parlour and Seppi (2008) for a survey of recent research on limit order markets. We trace the notion that limit orders are uninformed and market orders are informed to Glosten (1994), who provides an early model of a limit order market.

[5]An early model by Chakravarty and Holden (1995) allows for informed limit orders and shows that informed traders may combine market buy orders with limited sell orders to provide a bound on the potential losses associated with market orders. Harris (1998) analyzes limit-order strategies for different traders and shows that limit orders may be optimal for informed traders. However, he does not place his analysis in an equilibrium setting.

chases executed in electronic limit order markets. The key question is whether firms supply or consume liquidity when they repurchase shares. The connection between this question and the question of whether firms are informed or not may be tenuous are even non-existent. In our data, we cannot observe the orders firms use to execute open market repurchases. Instead, we formulate two hypotheses that motivate firms' choice between consuming liquidity and providing liquidity based on the preceding discussion.[6]

First, the choice between liquidity-consuming market orders and liquidity-providing limit orders rests on the size of the repurchase transactions. Market orders bear price risk and firms may pay a high spread for immediate execution if the depth at the prevailing quotes is smaller than the repurchase transaction, leading firms to prefer limit orders for larger transactions. By contrast, market orders guarantee immediate execution at the prevailing quotes if they are sufficiently small and may be suitable for smaller repurchases. Hence, firms should resolve the trade-off between execution risk and price risk differently depending on the transaction size. The *repurchase-intensity hypothesis* therefore postulates that firms supply liquidity to the market if they repurchase a large number of shares in any given period and they consume liquidity if they repurchase a smaller number of shares.[7].

Second, the choice between supplying and consuming liquidity may depend on the liquidity of the market itself. According to the gravitational-pull model of Cohen, Maier, Schwartz, and Whitcomb (1981), market orders become more advantageous if the market is already very liquid, because the costs of placing market orders converge to zero as the spread becomes arbitrarily small. By contrast, limit orders are advantageous in illiquid markets, because they allow traders to avoid paying the spread.[8] Traders thereby move the spread towards some

[6]We equate this dichotomous choice with the choice between market orders and limit orders and do not consider hybrid strategies in which firms would post market buy orders and protect themselves against price risk by posting simultaneous limit sell orders. See Chakravarty and Holden (1995) for an argument for such hybrid strategies.

[7]Several authors describe the trade-off between immediacy and execution risk. Foucault, Kadan, and Kandel (2005) trace it back to Demsetz (1968). Kaniel and Liu (2006) make a similar point and argue that the resolution of the trade-off depends on order size. Many authors, including Bloomfield, O'Hara, and Saar (2005), Foucault, Kadan, and Kandel (2005), and Kaniel and Liu (2006) also emphasize the importance of the time horizon, with limit orders being preferred by more patient traders.

[8]We trace this argument to Cohen, Maier, Schwartz, and Whitcomb (1981). The notion that limit orders

central level. In the context of share repurchases, the *gravitational-pull hypothesis* postulates that repurchasing firms consume liquidity if the spread in the market is below a critical threshold, and they supply liquidity otherwise.

We collect monthly data on all stock repurchases from all US companies since 2004 from SEC forms 10-Q and 10-K and compute five different liquidity measures, of which three rely on different definitions of the bid-ask spread. The others are the 5-minute price impact and the Amihud illiquidity measure. Our data set covers 6,170 firms and 348,121 firm-months. Of these 2,942 firms conduct at least one repurchase during our sample period.

Our analysis provides strong support for both hypotheses. On average share repurchases provide liquidity, but the relationship depends strongly on the repurchase intensity. Depending on the liquidity measure and the method we use, the 50% to 70% smallest repurchases consume liquidity, i.e., they lead to wider spreads and higher price impact. By contrast, the larger repurchases create liquidity, in line with the prediction of the repurchase-intensity hypothesis. Hence, only firms that execute large repurchases become net suppliers of liquidity. This finding supports the repurchase intensity hypothesis and shows that firms that execute large repurchases act as competing market-makers in the sense of Barclay and Smith (1988).

Regressions in which we condition on the liquidity of the market in the previous month support the gravitational-pull hypothesis. Repurchases consume liquidity only if firms are in the lowest spread quintile, whereas repurchases enhance liquidity for the other, less liquid firms.

We also revisit the notion that repurchases may lead to a deterioration in liquidity because companies make use of privileged information. We adapt the methodology used in the insider trading literature and measure the information content of repurchases by using abnormal stock returns after repurchases. Interestingly, the previous literature took the link between asymmetric information and a reduction in liquidity for granted and never investigated whether liquidity-consuming repurchases actually reveal more information than

become comparatively advantageous if the market would otherwise be less liquid recurs, among others, in Goettler, Parlour, and Rajan (2009).

liquidity-providing repurchases. In our sample, liquidity-consuming repurchases are on average followed by lower stock returns compared to liquidity-providing repurchases. This finding is inconsistent with the informed-trader hypothesis and the notion that information-based repurchases reduce market liquidity, but it resonates well with the recent findings in the microstructure literature that informed traders supply liquidity by placing market orders. In addition, our measurement of abnormal returns extends over periods ranging from one to six months and are statistically more pronounced for the longer period, which indicates that firms act as patient informed traders if they trade on any information at all.[9]

Our study contributes to the literature on repurchases and liquidity in several ways. First, we reformulate the underlying theory in light of recent research on limit order markets. Our discussion adapts the competing market-maker hypothesis of Barclay and Smith (1988). However, our hypothesis development deviates from theirs because we do not link strategies that consume liquidity with asymmetric information. Second, we investigate the extent to which more informed repurchases lead to a larger deterioration of liquidity by using event-study methodology. Third, ours is the first study that is based on a comprehensive sample of realized share repurchases in the US. Previous papers rely either on repurchase announcements or manually collect only a small subset of the information available from SEC filings.[10] Fourth, we provide some perspective of why previous research has been inconclusive. Between one half and three quarters of the repurchases in our sample consume liquidity and the others provide liquidity, especially larger repurchases and those of smaller and less liquid firms. Based on our analysis, we attribute the diverging results in the literature to differences in the sample and methodology, which we discuss in more detail below.

The following section describes our data collection procedure and outlines our methodology. Section 3 contains the core of our analysis. Section 4 extends the analysis, provides

[9] Bloomfield, O'Hara, and Saar (2005) and Kaniel and Liu (2006) both show in different contexts that informed traders use limit orders and supply liquidity when their information is sufficiently long-lived and their informational advantage is not too large.

[10] Cook, Krigman, and Leach (2003) collect data from companies and Ben-Rephael, Oded, and Wohl (2012) collect data manually from filings.

some additional robustness checks, and discusses identification issues. Section 5 concludes. The appendix provides some additional technical material.

2 Data and methodology

Sample construction. New disclosure requirements in the US mandate the publication of monthly share repurchases under the new Item 2(e) of Form 10–Q and under the new Item 5(c) of Form 10–K. The requirement applies to all periods ending on or after March 15, 2004. Under these rules firms have to report the total number of shares purchased, the average price paid per share, the number of shares purchased under specific repurchase programs, and either the maximum dollar amount or the maximum number of shares that may still be purchased under these programs. The difference between the total number of shares purchased and the number of shares purchased under repurchase programs are often shares delivered back to the issuer for the payment of taxes resulting from the vesting of restricted stock units and the exercise of stock options by employees and directors. Besides the number of shares purchased and the purchase price, firms have to indicate the method of repurchase (e.g., open market repurchase, private transaction, tender offer).

We use the CRSP monthly stock file as a starting point to construct our data set. We identify all ordinary shares (share code 10 and 11) that are traded on the NYSE, AMEX, and NASDAQ (exchange code 1, 2, and 3), which gives us 6,504 firms over the period from January 2004 to December 2010. We merge CRSP with Compustat and lose 18 firms that are not available in Compustat in this step. Furthermore, we drop 171 firms with missing data on the central index key (cik), the main identifier of the Securities and Exchange Commission. This leaves us with a sample of 6,315 firms that can be found on CRSP, Compustat, and Edgar.

For all firms we use a computer script to download all 10-Q and 10-K filings that were filed between January 1, 2004 and March 31, 2011. In total we obtain 96,203 10-Qs and

34,589 10-Ks and extract the repurchase data from these filings. Since many firms do not adhere to the proposed disclosure format, we manually check and correct all observations. This procedure leaves us with 376,843 firm-month observations. Among these are more than 20,000 firm-months with missing CRSP data if the firms are no longer or not yet listed on AMEX, NASDAQ, or NYSE at the time of the repurchase.

In the last step we merge the data with I/B/E/S and TAQ using historical CUSIP numbers. From CRSP we obtain closing prices, number of shares outstanding, number of shares traded, and daily and monthly stock returns. From Compustat we obtain data on total assets, book value of equity, book value of debt, operating income before depreciation, and S&P 500 membership. Data on analyst coverage is from I/B/E/S. All liquidity measures are obtained from TAQ and explained below. We eliminate all observations from the final sample for which the variables used in the baseline analysis are not available; the variables included in the baseline analysis are listed in Table 3. Table 2 shows the number of observations, the number of firms, the number of repurchasing firms, and the number of repurchase months for each year and for the entire sample period for the baseline sample.

We are left with a sample of 6,170 firms of which 2,942 conduct at least one repurchase during our sample period. The analysis is based on observations of 346,888 firm-months and firms conduct share repurchases in 50,112 of these firm-months.

Methodology and variables. Our generic specification regresses a measure of stock market liquidity on measures of stock repurchases and a range of controls.

$$Liquidity_{t,i} = \alpha + \delta Liquidity_{t-1,i} + \sum_{j=1}^{j=M} \beta_j Repurchase_{t,j} + \sum_{l=1}^{l=K} \gamma_l Control_{t,i,l} + \mu_i + \eta_t + u_{t,i}. \quad (1)$$

Here, $Repurchase_j$ is one of M repurchase measures included in the regression, $Control_l$ is one of K control variables, μ_i is a time-invariant firm fixed effect, and η_t is a year dummy.[11] We use five different measures of stock market liquidity. All intraday data for the calcula-

[11] In unreported regressions we repeat the analysis with monthly dummies and obtain very similar results.

tion of these measures are obtained from TAQ. The first three measures are based on the relative spread and the other two measures approximate the price impact of transactions in a particular stock. The precise details of how these measures are calculated are provided in the appendix and we only summarize them here. For all measures we first calculate a daily average and then the mean over all trading days within a particular month. We calculate the relative quoted spread based on the best bid and offer prices. The *time-weighted spread* is based on all relative spreads for a given stock, weighted by the time the quote is valid. For the *transaction-based spread* we associate each transaction with the spread that is valid within one second before the transaction and calculate the daily average of all spreads obtained in this way. The *effective spread* is calculated as twice the relative difference between the transaction price and the mid-point of the quotes and then averaged over all transactions within a day. We calculate *price impact* as the absolute value of the change in quotes over a five-minute interval and the *Amihud* measure as the absolute daily return, divided by trading volume in dollars. All five measures of liquidity can be calculated on a high-frequency basis. We do not use measures that can only be calculated for longer intervals or that have no relationship to the theory of limit order markets, on which we base our hypotheses.[12]

In our baseline specification we use two repurchase measures. The first is a dummy variable $RD_{t,i}$ ("repurchase dummy"), which is one for firm i in month t if the firm repurchased shares in that month. The second repurchase variable $RI_{t,i}$ is a measure of repurchase intensity and defined as the number of shares repurchased during the month divided by the number of shares outstanding at the beginning of the month. The correlation between these two repurchase variables is 0.52, which is not large enough to justify concerns about multicollinearity. In other specifications we scale the number of repurchased shares with trading volume or measure repurchase intensity by defining a dummy variable for each intensity quintile. Most contributions to the recent literature on the impact of repurchases on liquidity

[12]Examples would include the PIN measure of Easley, Kiefer, and O'Hara (1997) and the zero-return measure of Lesmond, Ogden, and Trzcinka (1999). We have no hypotheses regarding market depth.

base their research design on Brockman and Chung (2001).[13] They only use the repurchase dummy $RD_{t,i}$. However, our hypotheses emphasize the cross-sectional variation across repurchases and identify repurchase intensity as a key explanatory variable. For consistency with the literature we also repeat the analysis with the repurchase dummy only.

All the regressions include the same 14 control variables, which are defined and motivated in the discussion of Table 4. Brockman and Chung (2001) do not address endogeneity concerns and include contemporaneous stock volatility and trading volume as controls. In our baseline specification we address endogeneity concerns by also including firm fixed effects and the lagged dependent variable $Liquidity_{t-1,i}$. Brockman, Howe, and Mortal (2008) show that liquidity affects repurchase announcements in an analysis based on annual data. In their analysis, higher liquidity in one year increases the likelihood that firms initiate a repurchase program in the subsequent year. We confirm below that the relationship between repurchase intensity and lagged liquidity is highly significant. That analysis also shows that only very little of the variation in share repurchases can be explained using a range of explanatory variables that have been suggested in the literature. This paucity of explanatory power precludes the use of the exogenous explanatory variables for repurchases as instruments and all candidate instruments turn out to be weak. We therefore rely on firm fixed effects and the lagged dependent variable as controls for endogeneity. Moreover, we also lag the controls for stock volatility and trading volume because we suspect that these variables are affected by stock repurchases and may act as a transmission channel for the impact of share repurchases, which we do not wish to control for. In Tables 12 and 11 we provide specifications that reproduce those in the earlier literature and also show that volatility and trading volume depend on past repurchases.

Table 3 provides descriptive statistics for all variables used in the analysis. All distributions refer to the distribution over all firm-months in the sample except in those cases where we indicate that the distribution is based only on repurchase months. All liquidity

[13]The studies by Chung, Isakov, and Perignon (2007), Ginglinger and Hamon (2007), and Rasbrant and De Ridder (2011) replicate the research design of Brockman and Chung (2001) with minor modifications.

measures except the Amihud illiquidity measure display substantially higher average spreads than median spreads, which indicates skewed distributions. While the time-weighted spread is on average (median) 1.05% (0.27%), the transaction-based spread and the effective relative spread are 2.43% (0.93%) and 2.06% (0.62%) respectively, which is more than twice as high. This seems plausible given that the time-weighted spread is based on the National Best Bid and Offer (NBBO), whereas the transaction-based spread is based on the quote of a specific exchange which can never be smaller than the NBBO. The average repurchase volume over 50,112 repurchase months is $49.4 million. This is equivalent to buying back 0.66% of shares outstanding or 6.71% of monthly trading volume.[14]

3 Analysis

In the following three sections we test the three hypotheses mentioned in the introduction, namely, the repurchase-intensity hypothesis (Section 3.1), the gravitational-pull hypothesis (3.2), and the informed-trader hypothesis (3.3).

3.1 The repurchase intensity hypothesis

3.1.1 Parametric analysis

Our baseline specification includes the repurchase dummy and repurchase intensity. The discussion focuses on the time-weighted spread as the main liquidity measure. All results for the baseline specification are reported in Panel A of Table 4. The repurchase dummy is positive and significant for the time-weighted spread and for Amihud, but is insignificant for the other liquidity measures. By contrast, a higher repurchase intensity unequivocally reduces the spread and improves liquidity according to all five measures. These results suggest that small repurchases reduce liquidity and larger repurchases improve liquidity, in line with Hypothesis 1 (Repurchase intensity). For the three spread measures and the

[14]Ben-Rephael, Oded, and Wohl (2012) restrict their sample to firms in the S&P 500. If we do the same we obtain descriptive statistics that are very similar to theirs.

Amihud illiquidity measure we can calculate the break-even point above which repurchases have a net positive impact on liquidity, which is reported at the bottom of the table.[15] It is 0.46% for the time-weighted spread and the TAQ spread, 0.40% for the effective spread, and 0.84% for Amihud. Recall that repurchases are measured as a percentage of the shares outstanding, which has a median of 0.35% from Table 3; the 70th percentile is 0.67% and the 75th percentile is 0.80%. Hence, repurchases that are smaller than the median repurchase reduce the time-weighted spread and the three lowest quartiles of repurchases increase price impact according to the Amihud measure.

Economic significance. The coefficient on repurchase intensity with the time-weighted spread as the dependent variable is -1.793, which implies that a one percent increase in repurchase intensity reduces the spread by approximately 1.8%, calculated as a percentage of the spread itself; the mean time-weighted spread is 1.06% in our sample, so the reduction corresponds to about two basis points. The standard deviation of repurchase intensity is 0.98%, hence the coefficient is approximately the impact of a one-standard deviation change in repurchase intensity. To gauge whether this number is large or small, we compare the impact to some of the control variables. The most significant control variables are the market capitalization of the firm, the absolute level of the stock price, and the number of analysts. All these variables are expressed in logarithms. The 1.8% decline in the spread could be obtained with a 11.7% (=0.018/0.154) increase in market capitalization, a 25.6% (=0.018/0.070) increase in the level of the stock price, and a 81.5% (=0.018/0.022) increase in the number of analysts. Since all regressions include fixed effects, the impact of repurchase variables and control variables measures within-firm variation and should therefore be compared to the within-firm standard deviations of these variables. Further calculations show that a one-percentage point increase in repurchase intensity has the same impact on spreads as a 0.22 standard deviation increase in log market capitalization, a 0.71 standard deviation increase

[15] We determine the break-even points as $-\hat{b}_{RD}/\hat{b}_{RI}$, where $\hat{b}_{RD}$ and $\hat{b}_{RI}$ are the regression estimates of the coefficients on the repurchase dummy and repurchase intensity, respectively.

in the log stock price, and a 1.53 standard deviation increase in the logarithm of the number of analysts. The impact of repurchases on the spread is therefore of a similar magnitude compared to that of the most important control variables.[16]

Controls. Our regressions control for size using the logarithms of market capitalization and the book value of assets, and both measures imply that larger firms are more liquid, which confirms earlier findings of Stoll (2000) and Chung, Elder, and Kim (2010). Firms in the S&P 500 and with higher levels of the stock price also tend to be more liquid. In line with, Chung, Elder, and Kim (2010), we control for the number of analysts. In order to avoid a high number of missing observations, we assume that a firm has no analyst coverage if there is no information about the firm in I/B/E/S. We find that firms are more liquid if more analysts follow the stock; Chung, Elder, and Kim (2010) conjecture the same relationship, but find the opposite.

Firms are consistently less liquid in years when their book-to-market ratio is high. Results are less clear for leverage, where three liquidity measures show liquidity improvements and the other two indicate the opposite. Leverage typically does not change significantly over a seven-year period, so the impact of leverage has probably no meaningful interpretation. The negative coefficient on *Volatility* is difficult to interpret. We attribute the unexpected sign to the fact that we use lagged volatility. In Table 10 we show that we obtain the usual positive coefficient if we control for contemporaneous volatility.

We also control for transaction characteristics. Specifically, we include dummies for accelerated share repurchases (ASRs), repurchases conducted as tender offers, and privately targeted share repurchases.[17] However, none of the transaction characteristics has any con-

[16] The within-firm standard deviation of the logarithm of market capitalization is 0.53 and is obtained as the standard error of a regression of log market capitalization on firm fixed effects. The change in log market capitalization, measured in terms of within-firm standard deviations, required to obtain the same impact on the spread as a one percentage point increase in repurchase intensity is $\frac{-\beta_{RI}}{\beta_{MCAP}} \frac{0.01}{0.53} = \frac{1.793}{0.154} \frac{0.01}{0.53} = 0.22$, where β_{RI} and β_{MCAP} are the regression coefficients on repurchase intensity and log market capitalization from Table 4. The results in the text for the log stock price and the log number of analysts are obtained similarly; their within-firm standard deviations are 0.36 and 0.53, respectively.

[17] Accelerated share repurchases (ASRs) involve a contract with an intermediary who borrows the shares, delivers them to the firm, and immediately covers its short position through repurchases in the open market.

sistent and significant effect on liquidity. The stock market return over the previous month has a highly significant impact on stock liquidity.

We also control for three lagged variables. The lagged dependent variable is highly significant and large with autoregressive coefficients between 0.53 (Amihud) and 0.82 (transaction-based spread). We include the lags of stock volatility and trading volume, which is defined excluding share repurchases. These variables are commonly used as controls for the spread in the microstructure literature.[18] The direction of causality between volatility, liquidity, and trading volume are not clear and these variables are probably determined simultaneously. We therefore use lags of these controls and show results on simultaneous controls in the robustness section.

We add the same set of control variables to all specifications in the remaining part of this paper. We also include the same dummy variables and the lagged dependent variable. It turns out that the results for the control variables are virtually identical across specifications and we do not report results on controls to conserve space.

Alternative specifications. We analyze an alternative specification in which we enter only the repurchase dummy RD and omit the repurchase intensity RI. This regression is the most common specification used in the literature. We show the results in Panel B of Table 4. We find a negative impact of repurchases for all measures except *Amihud*, but the relationship is significant at the 5%-level only for the time-weighted spread. Since small repurchases reduce liquidity and large repurchases improve liquidity, the coefficient on RD measures the average impact of all repurchases, which is ambiguous and often insignificant. As hypothesized, including repurchase intensity is important and we therefore include it in our baseline specification.

See Bargeron, Kulchania, and Thomas (2011) for a more detailed discussion of ASRs.

[18] Cf. Stoll (2000) and also Brockman and Chung (2001), and Ginglinger and Hamon (2007)

3.1.2 Non-parametric analysis

The analysis in Table 4 is parametric and shows that small repurchases consume liquidity whereas large repurchases provide liquidity. However, the last conclusion is somewhat weak because the coefficient on the repurchase dummy is significant only in two out of five cases. It is therefore not clear that there is a significant number of sufficiently small repurchases that actually consume liquidity.

Table 5 repeats the analysis, but now measures repurchases by defining quintile dummies. The dummy variables for quintiles 1 to 5 are defined after sorting repurchases into quintiles, so that the dummy variable for Quintile n equals 1 if the repurchase intensity of a firm in a particular month falls into the n-th smallest 20% of the distribution, and zero otherwise. Quintile 1 therefore contains the smallest and Quintile 5 the largest repurchases relative to the number of outstanding shares. Non-repurchase months are not sorted into quintiles.

The results in Table 5 show that the smallest repurchases always consume liquidity, whereas the repurchases in the two top quintiles always provide liquidity. The results for the extreme quintiles are statistically significant at least at the 5% level and often at the 1%-level. The difference of Quintile 1 and Quintile 5 is shown at the bottom of the table and is always significantly different from zero at the 1%-level. The impact of repurchases in the second and third quintiles is ambiguous. Note that the coefficients decline from the largest and positive coefficient for the first quintile to the smallest and negative coefficient for the fifth quintile. The decline is strictly monotonic for all liquidity measures and the sign reversal is between the second and third quintile for all liquidity measures except for Amihud. These results suggest also that a little less than half of the repurchases consume liquidity and the majority of all repurchases provides liquidity, in line with the previous result that on average, repurchases improve liquidity.

Repurchase intensity and firm size. The previous analysis reveals that there is significant heterogeneity of share repurchases and their impact on liquidity across firms. In Panel B

of Table 5 we analyze the heterogeneity in terms of firm size. Here we sort firms into firm size quintiles from the smallest firms (Cap Q1 in the table) to the largest firms (Cap Q5) according to the market capitalization of the previous month. We interact the firm size quintile dummies with the repurchase dummy. The main finding is that the impact of share repurchases on liquidity strongly depends on firm size. Share repurchases on average provide liquidity for the smallest four firm size quintiles according to all five liquidity measures, and the effect is statistically highly significant in most cases except for the Amihud measure. By contrast, repurchases negatively impact liquidity deteriorates for the largest firm size quintile, and the effect is highly significant for three measures (transaction-based spread, time-weighted spread, and Amihud) and marginally significant for the effective spread. Hence, we conclude that firm size plays a major role. This may be one of the reasons why the prior literature finds inconsistent results, because the studies used in previous papers differ in terms of the size of the firms that are selected into the sample.

Next, we interact repurchase intensity with firm size by defining dummy variables for large firms (market capitalization above the median) and small firms (market capitalization below the median). We then interact the firm size dummies with the intensity quintile dummies in Panel C of Table 5. While the qualitative patterns are similar for large firms and for small firms, there are some notable differences. The last lines of the table calculate the difference between Repurchase quintile 1 and Repurchase quintile 5 for small firms and for large firms separately. These calculations show that the coefficients increase consistently from Repurchase quintile 1 to Repurchase quintile 5 for all five liquidity measures and for small firms as well as for large firms. The difference is much larger for small firms, where it is between three times (effective spread) and ten times (transaction-based spread) larger compared to the large firms in the sample.

More importantly, the sign reversal occurs for small firms always between the first and second quintiles, indicating that at most the 20% smallest repurchases consume liquidity, whereas for large firms the sign reversal occurs between the third and fourth quintile (effective

spread, price impact), between the fourth and fifth quintile (time-weighted spread, Amihud), or not at all (transaction-based spread), which indicates that most repurchases consume liquidity for large firms. Hence, while most repurchases consume liquidity for large firms, they mostly provide liquidity for small firms. One possible interpretation is that small firms are less liquid so that even smaller repurchase programs are executed using limit orders, whereas larger and more liquid firms execute repurchases using market orders. If this interpretation is correct, then firm size may simply proxy for market liquidity and the size-related patterns in Table 5C may reflect the gravitational-pull effect; we analyze this effect further in Table 6. In untabulated regressions we perform a related parametric analysis by interacting repurchase intensity with the logarithm of market capitalization. If repurchases have a stronger negative impact for smaller firms, then the coefficient on this interaction should be positive, which is indeed what we find.

The coverage of our data set differs from the previous literature because we use all US firms for which we can obtain complete data, including many small firms. The results in Table 5 suggest that firm size may be critical for the general result that repurchases on average improve liquidity. In the Introduction we cite several studies for non-US samples that find the opposite and the results in the literature are ambiguous. If we would restrict our sample to the largest firms then we would also find the opposite results. It may be that the non-US samples studied in the prior literature cover mainly larger firms and therefore find different results.

3.2 The gravitational-pull hypothesis

According to the gravitational-pull hypothesis of Cohen, Maier, Schwartz, and Whitcomb (1981), investors will always place orders so that they consume liquidity if liquidity is above a certain threshold, and provide liquidity if liquidity is below such a threshold (Hypothesis 2). We test this hypothesis for firms conducting repurchases as follows. For each calendar month in the sample we sort all firms into quintiles according to the level of the time-weighted

spread in that month, independently of whether the firm repurchased shares in that month or not. We then assign dummy variables to the spread quintiles based on the spread in the previous month, such that the 20% of firms with the lowest spreads in the previous month are assigned to Spread Q1 (quintile 1). We then include these spread quintile dummies as well as their interactions with the repurchase dummy RD. The prediction of the gravitational-pull hypothesis is that the coefficient on these interactions is negative for high spread quintiles (repurchases improve liquidity of low-liquidity shares) and positive for lower spread quintiles (repurchases consume liquidity of high-liquidity shares).

Panel A of Table 6 presents the results. The coefficients on the interactions are positive for the first quintile and negative for Spread Q3 to Spread Q5. Most interactions are highly significant for Spread quintiles 3 to 5. The patterns are strictly monotonic for all liquidity measures except Amihud between Spread Q1 and Spread Q4. The results in Panel A of Table 6 are therefore remarkably consistent with the gravitational-pull hypothesis.

All quintiles in Panel A of Table 6 are constructed based on the time-weighted spread. In Panel B of Table 6 we repeat the same exercise, but sort firm-months into quintiles according to the liquidity measure used as the respective dependent variable. E.g., for regression (2) with the transaction-based spread as the dependent variable, we sort firms into quintiles based on the transaction-based spread in the previous month. In Panel B we see very similar patterns to those in Panel A for all liquidity measures except for price impact, for which most coefficients are insignificant. For all other liquidity measures the sign reversals between the smallest and largest quintiles still obtain and for the three spread measures we have almost strict monotonicity, the only exception being Spread Q4 for the effective spread. Overall, the results of Table 6 strongly support the predictions of the gravitational-pull hypothesis of Cohen, Maier, Schwartz, and Whitcomb (1981) for share repurchases.

3.3 The informed-trader hypothesis

In this section we analyze whether the information content of share repurchases explains how repurchases affect market liquidity. The informed-trader hypothesis of Barclay and Smith (1988) relies on the earlier models following Glosten and Milgrom (1985) and postulates that firms consume liquidity when they trade on privileged information. This approach equates informed trading with a strategy that uses market orders. By contrast, the theory of limit order markets discussed in the Introduction implies that informed traders may prefer limit orders to market orders. Bloomfield, O'Hara, and Saar (2005) argue that informed traders may use limit orders because they are least subject to adverse selection and do not run the risk of having their limit orders picked off by more informed traders.

The relevance of the longevity of information seems to be model dependent. In the models of Harris (1998) and Kaniel and Liu (2006), investors place limit orders if they have long-lived inside information, but switch to market orders if their informational advantage is only short-lived and needs to be exploited quickly. By contrast, the model of Goettler, Parlour, and Rajan (2009) does not generate this prediction and even short-lived information may be exploited by placing limit orders. How the impact of repurchases on liquidity depends on the informational advantage of the company relative to other investors is therefore an empirical question. We use three different methods to analyze the relationship between information and liquidity and to test the informed trader hypothesis: (1) an event-study analysis of disclosure-date returns, (2) an investigation into how liquidity in the repurchase month depends on information as measured by subsequent cumulative abnormal stock returns, and (3) an analysis of the relationship between unexpected changes in liquidity and subsequent stock returns.

Event studies around the filing date. The first method we employ for testing the informed trader hypothesis builds on the premise that the information content of repurchases should be revealed in stock price changes at the disclosure date. If the market interprets

repurchases as signals about insiders' information, then the disclosure of actual repurchases in 10-Q and 10-K filings should cause stock price reactions. We assume that the filing date is also the date around which the information about actual repurchases becomes public and perform a standard event study. Cumulative abnormal returns (CARs) around the filing date are calculated from a market model using daily data with an estimation window of 200 days and a minimum of 100 days of stock return data. Disclosure day returns are calculated around the filing date in which the repurchase is published by the company. We calculate the CAR from one day before to one day after the filing. Filings are quarterly and filing dates are typically about six weeks after the end of the quarter. For example, a firm may disclose share repurchases executed in January by mid-May, when it files the 10-Q statement for the first quarter. We then associate the CAR for the three days around the filing date in May with the average liquidity of the stock on all trading days in January. The dependent variables are the liquidity measures in the repurchase month and the independent variables include the repurchase dummy, the *Filing CAR*, the interaction of *RD* with *Filing CAR*, and the usual controls.

Table 7 presents the results. The coefficient of interest is the interaction between *Filing CAR* and the repurchase dummy. Under the informed trader hypothesis of Barclay and Smith (1988), the the coefficient on the interaction should be positive: A higher value of *FilingCAR* shows that repurchases are more informative, and they should then reduce liquidity, i.e., increase the spread. Under the alternative hypothesis that informed firms use limit orders to exploit their information, the coefficient on the interaction should be negative. The results contradict the informed trader hypothesis: For all liquidity measures, a higher abnormal filing day return is associated with *more* liquidity in the month of the actual repurchase. Hence, repurchases that tend to reveal more positive information to the market at the filing date tend to be associated with higher liquidity. This result lends support to the alternative hypothesis that firms provide liquidity rather than consume liquidity when they repurchase shares based on private information.

The effect of the repurchase dummy on all liquidity measures except Amihud is negative, i.e., liquidity improves in repurchase months, which is in line with the results from Table 4B. The direct impact of *Filing CAR* on liquidity is either insignificant or positive, but significant at the 5%-level only for Amihud.

Measuring cumulative abnormal returns after repurchase months. Our second approach is based on a standard procedure from the insider trading literature and identifies the information content of repurchases by looking at abnormal stock returns associated with repurchases after the repurchase month.[19] The insider trading literature uses abnormal announcement returns, typically beginning with the disclosure of insider trades, whereas we include also the period before the filing, assuming that information may become known to the market through other means, including repurchases themselves. We use the market model with the CRSP equally-weighted index and estimate the parameters based on 60 months of monthly data.

Table 8 presents two different sets of results that differ only with respect to the period over which we calculate cumulative abnormal returns (CARs). One difficulty is that we do not know at which point in the month a repurchase transaction took place, hence CARs that include the repurchase month itself may measure price changes before and after the repurchase. We exclude the repurchase month itself from the calculation of CARs and therefore miss the abnormal stock returns between the repurchase transactions and the last day of the repurchase month. This fact should at most create some noise in the CAR variable and give rise to attenuation bias, i.e., the coefficients would be biased towards zero. Table 8 presents results for CARs measured over the month subsequent to the repurchase month in Panel A and for CARs measured over the subsequent six months in Panel B.

We include CAR, the repurchase dummy RD, and the interaction of CAR with RD. The coefficient on RD has the same interpretation as before. The coefficient on CAR reveals how market liquidity responds to abnormal stock returns independently of whether these

[19] E.g., see Lakonishok and Lee (2001) and Fidrmuc, Goergen, and Renneboog (2006).

abnormal stock returns are related to repurchases or not. Our coefficient of interest is the one on the interaction term, which should be positive if firms execute repurchases with a higher informational content with liquidity-consuming market orders, and negative if firms provide more liquidity if the informational content of repurchases is larger. The control variables are the same as in previous regressions and always included, but not displayed in the table.

In both panels of Table 8 and for all liquidity measures we observe that the coefficient on the interaction term $RD * CAR$ is negative. For the six-months time horizon in Panel C, the interaction is always significant at the 5%-level or better; for the shorter time horizon, the interaction term is highly significant in three out of five cases. Hence, for horizons ranging from one month to half a year after the repurchase month, higher abnormal returns are significantly associated with larger liquidity improvements during the repurchase month itself. This finding contradicts the informed trader hypothesis, which predicts that repurchases with larger information content reduce liquidity.

Coefficients on the repurchase dummy are negative and insignificant for *Amihud*, somewhat weaker but still in line with previous findings. The coefficient on CAR itself is negative and significant at the 1%-level in all regressions. Hence, even firms that do not undertake a repurchase in a particular month experience higher CARs in subsequent month if the liquidity of their stock is higher today. Higher liquidity therefore seems to predict higher abnormal stock returns in the subsequent one to six months and the interaction term only reflects that this effect is stronger for repurchasing firms than for non-repurchase firms. A possible explanation may be that higher liquidity is associated with traders with long-lived positive information placing limit orders. This effect is stronger for repurchase months, but prevails also in non-repurchase months.

Unexpected changes in liquidity. The final and third approach to test the informed-trader hypothesis investigates if the informational content of repurchases can be related to changes in liquidity during the repurchase month. Based on the informed-trader hypothesis

we should expect those repurchases that enhance liquidity to predict lower CARs compared to repurchases that reduce liquidity. Under the informed-trader hypothesis, liquidity-reducing repurchases should generate larger positive stock returns in the future, because these are the repurchases that managers decided to execute quickly in order to take advantage of the stock's undervaluation.

We proceed as follows. To calculate liquidity surprises, we calculate expected liquidity according to all five liquidity measures by estimating a regression that is identical to the baseline regression in Panel A of Table 4, except that we omit the repurchase variables. The predicted values of this regression reflect the liquidity of the stock based on the control variables in Panel A of Table 4 and the residuals reflect the liquidity that cannot be forecasted with the control variables. We then divide the sample into those repurchase-months for which there is a positive liquidity surprise (spreads and price impact are lower than expected) and those with a negative liquidity surprise. We then calculate the same CARs as in Table 8 before, separately for positive and for negative liquidity surprises. Hence, we attribute the liquidity surprise in a repurchase month to the repurchase transaction in that month. Based on the informed trader hypothesis we expect that repurchase-months with positive liquidity surprises have lower CARs compared to repurchase-months with negative liquidity surprises.

Table 9 presents the results. For each liquidity measure the table shows the difference in CARs between repurchase-months with negative liquidity surprises (higher spreads) and positive liquidity surprises (higher spreads). According to the informed-trader hypothesis this difference should be positive. However, for all five liquidity measures and for both definitions of CARs we find that the mean and the median differences are negative. The average one-months CARs range between -0.11% and -0.30%, which amounts to -1.32% to -3.60% on an annualized basis; six-months CARs range on average between -0.81% and -1.63% (annualized: -1.62% and -3.26%) and therefore have a similar magnitude on an annualized basis, but are statistically stronger. Hence, repurchases that provide liquidity outperform repurchases that consume liquidity, which again runs counter to the informed-trader hypothesis.

Conclusion. We conclude from the discussion in this section that the information content of repurchases is not associated with information in the way predicted by the informed-trader hypothesis. To the contrary, higher information content seems to be associated with improvements and not with deteriorations in liquidity at the time repurchases were executed. While theoretical models do not specify how the notions of "long-lived" information and "short-lived" information should be operationalized, it seems fair to assume that the typical three-months gap between repurchases and the subsequent filings as well as the six-months period count as longer periods. Under this interpretation, the results support the predictions of the models of Harris (1998) and Kaniel and Liu (2006), who see patient informed traders as suppliers as liquidity. Our results are also in line with the empirical findings of Kaniel and Liu (2006) as well as the experimental findings of Bloomfield, O'Hara, and Saar (2005).

4 Extensions and robustness checks

In this section we address robustness and identification issues. Section 4.1 provides alternative specifications that are closer to specifications used in the extant literature and Section 4.2 discusses to what extent repurchases may be endogenous.

4.1 Comparison with other specifications

In the Introduction we cite the literature on share repurchases and liquidity, which finds inconsistent results, with a positive effect for some countries and a negative effect for others. The literature on the US in itself is inconclusive. In this section we discuss the methodological differences between our analysis and the extant literature and show how the research design influences the results.

We differ from the extant literature in terms of our methodology and in the coverage of our sample. The differences in coverage are already discussed above. In summary, our sample is broader than that of previous studies and we would expect samples that are restricted to

larger and more liquid stocks to show the opposite results for the impact of repurchases on liquidity. The main methodological difference is that we use lagged volume and lagged volatility as controls rather than their contemporaneous counterparts, because we regard them as endogenous and influenced by repurchase decisions. In this section we analyze how repurchases, volatility, and trading volume depend on each other and then repeat the baseline analysis with contemporaneous trading volume and volatility as regressors.

In Table 10 we regress trading volume and volatility on the repurchase variables and a range of other controls. We run four regressions for each dependent variable. In each case, the first regression uses the specification with the dummy variable RD and the intensity variable RI as in Table 4, the second specification uses the lags of RD and RI, the third specification uses the contemporaneous quintile dummies, and the fourth specification uses the lagged quintile dummies as in Table 5.

Based on the analysis of De Cesari, Espenlaub, and Khurshed (2011) we expect that repurchases reduce return volatility, and this is what we find for all specifications. All repurchase variables in regressions (1) to (3) in Table 10 are negative except for the contemporaneous repurchase intensity RI in regression (1). However, the contemporaneous repurchase dummy RD is negative there and the coefficients imply that for all repurchases smaller than 7.56% of the shares outstanding (0.032/0.421=0.0756), the impact of repurchases is negative. The 99th percentile of repurchases scaled in this way is only 4.55%, so that practically all repurchases lead to a reduction in volatility. A comparison of regressions (3) and (4) suggests that the impact of lagged repurchases is similar to that of contemporaneous repurchases, which makes it likely that the impact is causal because it is difficult to argue that repurchases react to future volatility. It is also unlikely that lagged repurchases pick up unobserved variation in firm characteristics since we include firm fixed effects.

With respect to volume we can formulate different hypotheses. Recall that trading volume is defined as the observed volume minus the volume of share repurchases in that month. We net out repurchases in order to avoid a mechanical relationship between volume and the

right hand side repurchase variables. Repurchases may have a negative impact on volume if firms crowd out other traders who may want to purchase the stock and whose limit orders now expire. We may also expect that repurchases affect non-repurchase volume indirectly through their impact on spreads. If repurchases reduce spreads, then they reduce transaction costs for other market participants and encourage trading in the firm's stock, and vice versa for repurchases that increase spreads Under this scenario, small (large) repurchases, which we have shown to reduce (increase) liquidity, also reduce (increase) trading volume. The results in regressions (5) to (8) in Table 10 show that the crowding-out effect dominates on average and trading volume ex repurchases declines in repurchase months. However, the decline in repurchase volume is lowest for largest repurchases, which are also associated with an improvement in liquidity, supporting the second explanation.

Table 11 provides a specification that is similar to the one used in the prior literature. We enter the log of contemporaneous dollar trading volume and the log of contemporaneous volatility into our baseline regression. Also, our definition of trading volume in Table 11 includes the repurchase volume itself, unlike all previous results. The coefficient estimates for the repurchase variables decline in absolute value for all liquidity measures and become insignificant for all measures except for the Amihud measure. Note that the coefficient on contemporaneous volatility is now positive, in line with the previous literature, whereas the coefficient on lagged volatility in Table 4 is negative. In the related strand of literature (cf. e.g. Brockman and Chung (2001); Ginglinger and Hamon (2007); Rasbrant and De Ridder (2011); Chung, Isakov, and Perignon (2007) it is common practice to include contemporaneous dollar trading volume and volatilty into the regression analysis of the spread. The specification used in the prior literature can be traced back to Stoll (2000) who analyzes the cross-sectional properties of the spread by regressing measures of the spread on market capitalization, stock price, number of trades, trading volume, and volatility. His results are in line with ours and those of the previous related literature and document a positive impact of volatility and a negative impact of dollar trading volume on the spread. Results become

insignificant only if we deviate from our prior specifications by using contemporaneous instead of lagged volume and by using the log dollar volume instead of the number of shares traded as a percentage of the shares outstanding.

We conclude from this analysis that share repurchases simultaneously affect return volatility, non-repurchase trading volume, and market liquidity, and that it is methodologically preferable to use the predetermined values of the endogenous variables as controls rather than their contemporaneous values.

4.2 What drives share repurchases?

The literature on share repurchases and liquidity does not address endogeneity concerns. However, it is conceivable that repurchases respond to changes in market liquidity, because from the perspective of firms the spread represents a transaction cost for executing repurchases. Brockman, Howe, and Mortal (2008) establish that liquidity also causes share repurchases. They study announcements of share repurchase programs and the choice between repurchases and dividends and conclude that firms prefer repurchases if the market for their stock is more liquid. Illiquidity represents transaction costs from the point of view of firms that conduct open market repurchases and firms prefer dividends when the illiquidity costs are too high and initiate share repurchases when the liquidity of their stock has improved.

In Table 12 we regress repurchases on lagged liquidity and a range of other control variables, including the past twelve monthly returns, the past three months' returns on the market index, as well as other firm and transaction characteristics. The main difference to Brockman, Howe, and Mortal (2008) is that they use annual data of repurchase announcements and lag liquidity by one year, whereas we use monthly data of realized repurchases. The dependent variable in regressions (1) and (2) is repurchase intensity and in regressions (3) and (4) it is the repurchase dummy. All regressions include firm fixed effects. We restrict the sample to firms that conduct at least one repurchase during our sample period.

Liquidity is measured by the time-weighted quoted spread, depth at the bid price, and

depth at the asking price, all lagged by one month. The results show that firms respond to improvements in liquidity by repurchasing more shares. The results for repurchase intensity are highly significant and have the predicted signs, whereas for the repurchase dummy the coefficients on the repurchase variables are mostly insignificant. Repurchases respond strongly to past stock returns. Based on the prior literature we expect a negative sign, because firms tend to repurchase more shares after their stock has declined.[20] All lags have the predicted negative signs, which are significant up to lags of order 8 or 9. Repurchases are related to changes in past market movements. Firms tend to repurchase more shares if they have stronger cash flows, which corroborates the findings of Jensen (1986) and Stephens and Weisbach (1998). Dittmar (2000) shows that firms use repurchases to increase leverage, which is consistent with our finding that firms with lower leverage conduct more repurchases. Bagwell (1991) develops a theoretical model to show that repurchases may serve as a takeover defense and Dittmar (2000) finds supporting evidence for this hypothesis by showing that there is a positive relationship between takeover attempts or takeover rumors and share repurchases. Our dummy variable *Target* equals one if the firm has been subject to a takeover announcement. Accordingly, we would expect a negative relationship if repurchases are effective at deterring takeovers, which is what we find. Repurchases are also negatively related to the firm becoming an acquirer, probably because repurchases and acquisitions are alternative uses of the same cash. Firms repurchase more shares if they issue convertibles, consistent with the findings of de Jong, Dutordoir, and Verwijmeren (2011). Finally, firms that repurchase stock conduct fewer seasoned equity offerings, which is intuitive.

Remarkably, the regression has very low explanatory power. If we do not include lagged dependent variables, the R-squared for the repurchase intensity is a mere 2.84% and for the linear probability model for the repurchases dummy it is 4.20%. Hence, the portion of the variation in repurchase activity that can be predicted with exogenous or at least predetermined variables is very small. It is for this reason that it is difficult to find reasonable

[20]See Brav, Graham, Harvey, and Michaely (2005), and Stephens and Weisbach (1998)

instruments for repurchases.

5 Discussion and Conclusion

We analyze the relationship between stock repurchases and liquidity for a comprehensive sample of share repurchases during the period from 2004 to 2010. We find large cross-sectional variation with respect to the impact of repurchases on liquidity. Smaller repurchases consume liquidity, whereas larger repurchases provide liquidity. Liquidity provision prevails in smaller, less liquid firms and is less likely in larger and more liquid firms. We therefore find support for two hypotheses. First, one of the main variables driving the impact of repurchases on liquidity is the repurchase intensity itself. Second, liquidity provision is more (less) likely for less (more) liquid stocks. Repurchases seem to operate a "gravitational pull" of liquidity towards some central level. By contrast, all our evidence contradicts the predictions of the informed-trader hypothesis. Repurchases tend to provide liquidity if they contain more information. Using event study analysis, we show that those repurchases associated with a better post-repurchase stock-price performance also tend to improve liquidity more during the month of the transaction.

We interpret our findings in the context of recent research in market microstructure on limit order markets. Theoretical, experimental, and empirical studies concur that informed traders should and do make use of limit orders and provide liquidity to the market. Limit orders seem to be particularly useful for conducting share repurchases if the market is less liquid, if firms do not suffer from an informational disadvantage where other traders can pick off their orders, and when the intended repurchase volume is large. All our results are therefore plausible when interpreted in this context.

One of the limitations of our work is that we cannot observe firms' trading strategies. Hence, all our discussions of the use of limit orders and market orders relies on the analysis of liquidity measures and is therefore indirect. Future research might be able to collect data

on firms' trading strategies and analyze how firms' use of market orders and limit orders affects liquidity more directly.

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6 Appendix[21]

For all high frequency measures, we use the NYSE TAQ database to extract the necessary intraday transaction data. For each trade we assign the prevailing bid and ask quotes that are valid at least one second before the trade took place. If there is more than one transaction in a given second, the same bid and ask quotes will be matched to all of these transactions. If there is more than one bid and ask quote in a given second, we assume that the last quote in the respective second is the prevailing quote.[22]

For measures that are not based on transactions we use the NBBO (National Best Bid and Offer) quotes. The NBBO offer size is computed by aggregating all offer sizes at the best bid and best offer (=ask) over all U.S. exchanges (see WRDS website).[23]

The final data set contains the following items for each transaction:

1. Date and time stamp (up to seconds)
2. Transaction price (P_t)
3. Transaction volume in shares (w_t)
4. Prevailing bid quote (B_t)
5. Prevailing ask quote (A_t)

We calculate the quote midpoint price (Q_t) as the average of the prevailing bid and ask quotes ($Q_t = \frac{A_t+B_t}{2}$). We further use the algorithm of Lee and Ready (1991) to classify trades into buys and sells. We define trades with a transaction price above the quote midpoint ($P_t > Q_t$) as buys and those with a transaction price below the quote midpoint ($P_t < Q_t$) as sells. If a transaction price is equal to its quote midpoint, we compare the current transaction price with the previous transaction price. If $P_t < P_{t-1}$, we consider a trade to be seller-initiated; if $P_t > P_{t-1}$, we consider it to be buyer-initiated. Should the two prices be equal, we leave the trade unclassified.

[21] The description of the calculation procedures for the liquidity measures overlaps partially with those of Lebedeva, Olga, "Measuring and monitoring time varying information asymmetry", Working Paper, 2011, University of Mannheim.

[22] Henker and Wang (2006) consider this procedure to be more appropriate compared to the classical Lee and Ready (1991) five-second rule. Bessembinder (2003) tries zero to thirty-second delays in increments of five seconds and does not find any differences in the results.

[23] http://wrds-web.wharton.upenn.edu/wrds/research/applications/microstructure/NBBO%20derivation/

Time-weighted spread and transaction-based spread

We calculate the relative spread for each transaction as $RelativeSpread_t = \frac{A_t - B_t}{Q_t}$.We further aggregate the relative spreads of all transactions within a day for a particular stock. We use two different measures of the relative spread: The *time weighted spread* represents the daily average of all NBBO spreads for a given stock weighted by the time the quote is valid. The *transaction-based spread* is the daily average of all spreads that have been associated with a transaction via the one second matching approach described above.

Effective Spread

We calculate the effective relative spread of each transaction as

$EffSpr_t = 2\left|P_t - Q_t\right|/Q_t$. As with the relative spread, we take a daily average of all transactions for a particular stock.

Price Impact

We follow the approach of Riordan and Storkenmaier (2011) and define the price impact of each trade after 5 minutes as $PrcImp_t = 2\left|Q_{t+5} - Q_t\right|/Q_t$,where Q_{t+5} represents the quote midpoint price of the stock after five minutes (300 seconds). In the analysis we use the daily average of this measure for all stocks.

Amihud

The Amihud illiquidity measure is calculated by dividing the absolute daily return by trading volume denoted in dollars:

$$Amihud_t = \frac{|r_t|}{P_t \cdot Vol_t},$$

where

1. r_t represents the daily holding period return,
2. P_t represents the daily closing transaction price,
3. Vol_t represents the daily transaction volume.

Data for these calculations are from CRSP.

Table 1: Description of Variables. The table describes all control variables and some repurchase variables. For each variable the table reports the definition, the data source, and the unit of measurement. Variables denoted with (ln) are expressed as natural logarithms.

Name	Definition	Source	Unit
Acquiror	1 if firm is currently (time between announcement and end of the offer) bidding for another company	SDC	binary
Amihud	Monthly average of daily Amihud illiquidity ratio	CRSP	ratio
Analysts	Number of analysts (ln)	IBES	Unit
Accelerated share repurchase	Repurchase via accelerated share repurchase	SEC	binary
Book to market	Book value equity / market cap, winsorized at 1%	Comp.	ratio
Book value equity	Common equity (Compustat item: ceqq)	Comp.	million
Convertible issue	1 if convertible issue takes place in respective month	SDC	binary
Depth ask	Monthly average of intraday National Best Bid and Offer (NBBO) at the ask side (ln)	TAQ	unit
Depth bid	Monthly average of intraday National Best Bid and Offer (NBBO) at the bid side (ln)	TAQ	unit
Effective spread	Monthly average of intraday relative effective spread, transaction based (ln)	TAQ	ratio
Leverage	(Total asset - book value equity) / (total asset - book value equity + market cap)	Comp. /CRSP	ratio
Market cap	Monthly average of daily market capitalization (ln)	CRSP	million
Price	Monthly average of daily closing price (ln)	CRSP	unio
Price impact	Monthly average of intraday price impact, transaction based (ln)	TAQ	ratio
Private repurchase	Repurchase via private transaction	SEC	binary
Repurchase volume	number of shares repurchased during the month	SEC	million
Repurchase dummy	1 if repurchase transaction takes place	SEC	binary
Repurchase intensity	number of shares repurchased during the month divided by the number of shares outstanding at the last trading day of the previous month	SEC /CRSP	ratio
Repurchase intensity (TV)	number of shares repurchased during the month divided by the number of shares traded over the current month	SEC /CRSP	ratio
S&P 500 (D)	1 if firm is in the S&P 500	CRSP	binary
SEO	1 if SEO takes place in respective month	SDC	binary
Shares outstanding	Number of shares outstanding at last trading day of month	CRSP	million
Target	1 if firm is currently (time between announcement and end of the offer) a target of another company	SDC	binary
Trans.-based spread	monthly average of intraday relative spread, transaction based (ln)	TAQ	ratio

Table 1: Description of Variables. (continued)

Name	Definition	Source	Unit
Tender offer	Repurchase via tender offer or Dutch auction	SEC	binary
Total assets	Total assets (Compustat item: atq) (ln)	Comp.	million
Trading volume	Monthly total dollar trading volume (ln)	CRSP	million
Trading volume (scaled)	((number of shares traded) - (number of shares repurchased))/number of shares outstanding	CRSP /SEC	ratio
Time-weighted spread	monthly average of intraday relative spread, time-weighted (ln)	TAQ	ratio
Volatility	Standard deviation of daily returns over one month (ln)	CRSP	unit
EBITDA	Operating income before depreciation (Compustat item: oibdpq)	Comp.	million

Table 2: Breakdown of Sample. The table provides a breakdown of the sample by year. The columns display the total number of firms in the sample, the number of firms that repurchase shares in that particular year, the number of firm-months covered, and the number of months in which repurchases took place.

	Firms	Repurchasing Firms	Firm Months	Repurchase Months
2004	4,585	1,230	51,484	6,264
2005	4,599	1,427	51,475	7,732
2006	4,569	1,509	51,312	8,279
2007	4,592	1,687	50,644	9,145
2008	4,492	1,767	50,526	8,478
2009	4,223	974	47,234	4,576
2010	4,057	1,093	45,446	5,638
Total	6,170	2,942	348,121	50,112

Table 3: Descriptive statistics. The table provides descriptive statistics for the repurchase variables used in the baseline specification, the liquidity measures, and for the control variables. The appendix provides definitions of the liquidity variables. The repurchase variables and the control variables are defined in Table 1. *CAR (1 month)* is the cumulative abnormal return (CAR) of the respective stock in the month after the current month. *CAR (6 months)* is the cumulative abnormal return of the respective stock over the preceding six months. *Filing CAR (-1,+1)* is the cumulative abnormal return of the respective stock from t=-1 to t=+1 relative to the filing day of the 10-Q or 10-K report. We report the arithmetic mean, the median, the standard deviation (S.D.), the 1st percentile, and the 99th percentile of the distribution for each variable. None of the variables is expressed in natural logarithm.

	Mean	Median	S.D.	1^{st} Perc.	99^{th} Perc.	N
Liquidity measures						
Time-weighted spread	1.05%	0.27%	2.09%	0.02%	10.71%	346,888
Trans.-based spread	2.43%	0.93%	3.42%	0.08%	16.14%	346,888
Effective spread	2.06%	0.62%	3.92%	0.05%	19.45%	346,888
Price impact	2.30%	1.03%	3.55%	0.20%	17.03%	346,888
Amihud	5.14	0.01	178.45	0.00	62.95	346,888
Repurchase measures						
Repurchase volume (million)	49.4	4.6	181.9	0.0	768.8	50,112
Repurchase intensity	0.66%	0.35%	0.98%	0.00%	4.53%	50,112
Repurchase intensity (TV)	6.71%	3.28%	9.89%	0.00%	52.13%	50,112
Control variables						
Analysts	5.53	4.00	6.23	0.00	27.00	346,888
Accelerated share repurchase	0.00	0.00	0.15	0.00	0.00	346,888
Book to market	0.64	0.51	0.63	-0.87	3.80	346,888
Leverage	0.42	0.36	0.29	0.02	0.97	346,888
Market cap (million)	3230	345	15144	6	54895	346,888
Price	38.65	14.77	1346.08	0.42	92.70	346,888
Private repurchase	0.00	0.00	0.06	0.00	0.00	346,888
S&P 500	0.11	0.00	0.32	0.00	1.00	346,888
Tender offer	0.00	0.00	0.10	0.00	0.00	346,888
Total assets (million)	7308	516	64175	7	108585	346,888
Trading volume (million)	607	45	2772	0	9342	346,888
Trading volume (scaled)	17.62%	11.14%	32.49%	0.28%	103.06%	346,888
Volatility	0.03	0.03	0.03	0.01	0.13	346,888
Abnormal returns						
CAR (1 month)	-0.29%	-0.92%	15.44%	-36.15%	47.05%	291,527
CAR (6 months)	-1.70%	-2.65%	38.78%	-97.66%	119.01%	291,527
Filing CAR (-1,+1)	-0.08%	-0.10%	8.36%	-23.63%	23.67%	111,940

Table 4: Panel A. Liquidity and repurchases. The table presents regressions of five liquidity measures on repurchase variables and control variables. The appendix provides definitions of the liquidity variables. The repurchase variables and the control variables are defined in Table 1. Standard errors are clustered at the firm level. t-statistics are provided in parentheses. *, **, *** indicate significance at the 10%, 5% and 1% level respectively.

	Time-weighted Spread	Trans.-based Spread	Effective Spread	Price Impact	Amihud
Repurchase dummy	0.008***	0.003	0.006*	–0.000	0.042***
	(3.70)	(1.38)	(1.68)	(–0.01)	(8.38)
Repurchase intensity	–1.793***	–0.656***	–1.473***	–0.787***	–4.973***
	(–13.80)	(–4.51)	(–7.29)	(–4.46)	(–16.40)
Volatility$_{t-1}$	–0.010***	–0.043***	–0.026***	–0.013***	–0.085***
	(–4.76)	(–25.67)	(–10.07)	(–4.47)	(–11.01)
Trading Volume (scaled)$_{t-1}$	–0.049***	–0.031***	–0.058***	–0.053***	–0.230***
	(–6.13)	(–6.01)	(–5.98)	(–5.84)	(–6.21)
Market cap	–0.154***	–0.106***	–0.151***	–0.131***	–0.610***
	(–26.14)	(–26.11)	(–22.93)	(–21.11)	(–35.14)
Total assets	–0.011***	0.022***	–0.003	–0.006	–0.056***
	(–2.61)	(6.92)	(–0.63)	(–1.21)	(–4.46)
S&P 500	–0.026***	–0.008	0.019	0.011	0.064***
	(–2.88)	(–0.86)	(1.25)	(0.86)	(3.30)
Price	–0.070***	–0.040***	–0.038***	–0.033***	–0.157***
	(–14.24)	(–13.47)	(–7.21)	(–7.17)	(–13.35)
Analysts	–0.022***	–0.007***	–0.026***	–0.029***	–0.056***
	(–9.83)	(–3.43)	(–8.68)	(–9.77)	(–9.52)
Book to market	0.021***	0.012***	0.023***	0.033***	0.074***
	(8.88)	(6.40)	(8.25)	(11.19)	(10.15)
Leverage	0.009	–0.033***	–0.006	–0.024	0.168***
	(0.61)	(–2.95)	(–0.37)	(–1.35)	(3.66)
Accelerated share repurchase	0.001	0.000	–0.004	–0.004	–0.004
	(0.48)	(0.03)	(–0.62)	(–0.83)	(–1.05)
Private repurchase	0.003	0.001	0.003	0.007	–0.007
	(0.36)	(0.09)	(0.32)	(0.78)	(–0.56)
Tender offer	0.000	–0.012**	–0.007	–0.003	–0.026**
	(0.07)	(–2.23)	(–0.95)	(–0.42)	(–2.54)
Time-weighted spread$_{t-1}$	0.698***				
	(251.42)				
Transaction-based spread$_{t-1}$		0.821***			
		(418.51)			
Effective spread$_{t-1}$			0.708***		
			(209.23)		
Price impact$_{t-1}$				0.644***	
				(141.34)	
Amihud$_{t-1}$					0.533***
					(92.62)
Constant	–0.539***	–0.366***	–0.516***	–0.736***	2.132***
	(–25.00)	(–21.42)	(–18.80)	(–29.25)	(28.93)
R^2	0.766	0.801	0.657	0.597	0.731
Observations	345815	345702	343821	343996	346117
Firm FE	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes
Break Even Point	0.457%	0.457%	0.401%	–	0.843%

Table 4: Panel B. Liquidity and repurchases.

	Time-weighted spread	Trans.-based spread	Effective spread	Price impact	Amihud
Repurchase dummy	–0.005**	–0.002	–0.005	–0.006*	0.006
	(–2.41)	(–0.86)	(–1.52)	(–1.95)	(1.35)
Constant	–0.539***	–0.366***	–0.517***	–0.736***	2.125***
	(–25.02)	(–21.42)	(–18.81)	(–29.25)	(28.84)
R^2	0.766	0.801	0.657	0.597	0.730
Observations	345852	345739	343858	344033	346154
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes

Table 5: Panel A. Quintile analysis of repurchase intensity. The table presents regressions of five liquidity measures on non-parametric measures of repurchase intensity and control variables. The appendix provides definitions of the liquidity variables. *Repurchase intensity Qn* is equal to 1 if *Repurchase intensity* is in the n-th quintile. Panel B interacts *Repurchase dummy* with size quintile dummies (*Cap Qn*). *Cap Qn* is a dummy variable that equals 1 if the market capitalization of the firm was in the n-th largest quintile in the previous month. Market capitalization quintiles (*Cap Qn*) are also included in the regression but not tabulated. Panel C interacts dummy variables for repurchase intensity with a dummy variable for size. *Repurchase intensity Qn* is equal to 1 if *Repurchase intensity* is in the n-th quintile. *Small cap* (*Large cap*) is equal to 1 if the firm's market capitalization is below (above) the median market capitalization in the previous month. Standard errors are clustered at the firm level. t-statistics are provided in parentheses. The line "Quintile 1 - Quintile 5" reports the difference between the first and the last quintile and the significance of the Wald-test for whether this difference is statistically significantly different from zero. *, **, *** indicate significance at the 10%, 5% and 1% level respectively.

	Time-weighted spread	Trans.-based spread	Effective spread	Price impact	Amihud
Repurchase intensity Q1	0.022***	0.009**	0.022***	0.015***	0.085***
	(6.30)	(2.41)	(3.74)	(2.68)	(9.56)
Repurchase intensity Q2	0.011***	0.003	0.006	0.000	0.054***
	(3.49)	(0.98)	(1.19)	(0.02)	(7.89)
Repurchase intensity Q3	–0.002	–0.001	–0.000	–0.003	0.013*
	(–0.67)	(–0.33)	(–0.09)	(–0.68)	(1.89)
Repurchase intensity Q4	–0.014***	–0.006*	–0.013**	–0.016***	–0.022***
	(–4.50)	(–1.80)	(–2.57)	(–3.55)	(–3.46)
Repurchase intensity Q5	–0.035***	–0.011***	–0.033***	–0.021***	–0.084***
	(–11.41)	(–3.36)	(–6.68)	(–4.85)	(–12.89)
Quintile 1 - Quintile 5	0.057***	0.020***	0.055***	0.036***	0.169***
R^2	0.766	0.801	0.657	0.597	0.731
Observations	345815	345702	343821	343996	346117
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes

Table 5: Panel B. Quintile analysis of repurchase intensity.

	Time-weighted spread	Trans.-based spread	Effective spread	Price impact	Amihud
Repurchase dummy x Cap Q1	–0.018**	–0.023***	–0.012	–0.013	–0.040*
	(–2.42)	(–3.96)	(–1.28)	(–1.14)	(–1.74)
Repurchase dummy x Cap Q2	–0.028***	–0.017***	–0.019**	–0.023***	–0.005
	(–4.70)	(–3.53)	(–2.49)	(–2.73)	(–0.33)
Repurchase dummy x Cap Q3	–0.023***	–0.010**	–0.018**	–0.019***	–0.024***
	(–5.63)	(–2.37)	(–2.55)	(–2.71)	(–2.70)
Repurchase dummy x Cap Q4	–0.005	–0.006*	–0.012**	–0.006	–0.003
	(–1.56)	(–1.71)	(–2.22)	(–1.22)	(–0.56)
Repurchase dummy x Cap Q5	0.012***	0.013***	0.009*	0.005	0.025***
	(4.03)	(3.86)	(1.70)	(1.10)	(5.26)
Constant	–0.832***	–0.571***	–0.821***	–0.995***	0.731***
	(–43.82)	(–39.05)	(–35.30)	(–45.34)	(11.31)
R^2	0.764	0.800	0.656	0.596	0.724
Observations	345852	345739	343858	344033	346154
Quintile 1 - Quintile 5	-0.030***	-0.036***	-0.021*	-0.018	-0.065***
Controls	Yes	Yes	Yes	Yes	Yes
Cap Qn Dummies	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes

Table 5: Panel C. Quintile analysis of repurchase intensity.

	Time-weighted Spread	Trans.-based Spread	Effective Spread	Price Impact	Amihud
Small Cap_{t-1}					
x Repurchase Intensity Q1	0.035***	0.010*	0.033***	0.023**	0.159***
	(5.62)	(1.89)	(3.76)	(2.21)	(8.07)
x Repurchase Intensity Q2	0.000	–0.004	0.002	–0.005	0.063***
	(0.04)	(–0.62)	(0.19)	(–0.48)	(3.52)
x Repurchase Intensity Q3	–0.037***	–0.023***	–0.017*	–0.019*	–0.048**
	(–5.43)	(–3.63)	(–1.77)	(–1.73)	(–2.45)
x Repurchase Intensity Q4	–0.070***	–0.041***	–0.054***	–0.055***	–0.133***
	(–9.91)	(–6.00)	(–5.34)	(–5.17)	(–7.43)
x Repurchase Intensity Q5	–0.088***	–0.044***	–0.067***	–0.056***	–0.197***
	(–13.05)	(–6.64)	(–7.03)	(–5.89)	(–10.25)
Large Cap_{t-1}					
x Repurchase Intensity Q1	0.016***	0.009*	0.017**	0.012**	0.043***
	(4.02)	(1.82)	(2.33)	(1.97)	(6.61)
x Repurchase Intensity Q2	0.019***	0.008**	0.009	0.004	0.053***
	(5.45)	(2.00)	(1.42)	(0.71)	(10.27)
x Repurchase Intensity Q3	0.013***	0.010***	0.009	0.005	0.037***
	(3.92)	(2.67)	(1.28)	(0.96)	(7.02)
x Repurchase Intensity Q4	0.005	0.006	–0.000	–0.004	0.015***
	(1.44)	(1.51)	(–0.00)	(–0.80)	(2.83)
x Repurchase Intensity Q5	–0.018***	–0.001	–0.023***	–0.011**	–0.049***
	(–5.56)	(–0.27)	(–4.22)	(–2.33)	(–9.25)
Large Cap_{t-1}	0.028***	0.023***	0.021***	0.034***	0.059***
	(9.64)	(8.32)	(4.81)	(7.91)	(7.95)
R^2	0.766	0.801	0.657	0.597	0.731
Observations	345808	345695	343814	343989	346110
Small: Quintile 1 - Quintile 5	0.1227***	0.0539***	0.0998***	0.0795***	0.3562***
Large: Quintile 1 - Quintile 5	0.0339***	0.0097	0.0409***	0.0225***	0.0924***
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes

Table 5: Panel D. Quintile analysis of repurchase intensity.

	Time-weighted Spread	Trans.-based Spread	Effective Spread	Price Impact	Amihud
Small Spread_{t-1}					
x Repurchase Intensity Q1	0.015***	0.008*	0.018**	0.011*	0.044***
	(3.86)	(1.78)	(2.39)	(1.94)	(6.95)
x Repurchase Intensity Q2	0.017***	0.009**	0.014**	0.008	0.054***
	(4.97)	(2.25)	(2.18)	(1.55)	(10.23)
x Repurchase Intensity Q3	0.014***	0.011***	0.014**	0.009*	0.041***
	(4.25)	(2.99)	(2.08)	(1.76)	(8.11)
x Repurchase Intensity Q4	0.006*	0.006	0.004	–0.001	0.020***
	(1.84)	(1.60)	(0.75)	(–0.21)	(4.00)
x Repurchase Intensity Q5	–0.020***	–0.002	–0.022***	–0.010**	–0.045***
	(–6.54)	(–0.54)	(–4.08)	(–2.29)	(–8.86)
Large Spread_{t-1}					
x Repurchase Intensity Q1	0.034***	0.010*	0.031***	0.023**	0.148***
	(5.55)	(1.79)	(3.50)	(2.23)	(7.89)
x Repurchase Intensity Q2	0.003	–0.006	–0.008	–0.013	0.061***
	(0.48)	(–1.00)	(–0.87)	(–1.35)	(3.61)
x Repurchase Intensity Q3	–0.040***	–0.026***	–0.029***	–0.028**	–0.057***
	(–5.90)	(–4.18)	(–2.83)	(–2.57)	(–3.00)
x Repurchase Intensity Q4	–0.077***	–0.044***	–0.067***	–0.064***	–0.152***
	(–10.58)	(–6.27)	(–6.57)	(–5.95)	(–8.21)
x Repurchase Intensity Q5	–0.087***	–0.046***	–0.072***	–0.059***	–0.225***
	(–10.87)	(–6.39)	(–6.43)	(–5.20)	(–10.29)
Large Spread_{t-1}	0.005*	–0.011***	0.029***	0.021***	0.052***
	(1.90)	(–4.64)	(7.66)	(5.54)	(8.05)
R^2	0.766	0.801	0.657	0.597	0.731
Observations	345808	345694	343814	343989	345849
Small: Quintile 1 - Quintile 5	0.0357***	0.0104*	0.0398***	0.0213***	0.0895***
Large: Quintile 1 - Quintile 5	0.1208***	0.0560***	0.1032***	0.0824***	0.3725***
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes

Table 6: Panel A. Liquidity. The table presents regressions of five liquidity measures on dummy variables representing the liquidity of the stock in the previous month and control variables. The appendix provides definitions of the liquidity variables. The repurchase variables and the control variables are defined in Table 1. *TW Spread*$_{t-1}$ *Qn* is a dummy variable that is equal to one if the *time-weighted spread* of the stock was in the n-th highest quintile in the previous month. *Repurchase dummy x TW Spread*$_{t-1}$ *Qn* denotes an interaction between *Repurchase dummy* and *TW Spread*$_{t-1}$ *Qn*. Time-weighted spread quintiles (*TW Spread*$_{t-1}$ *Qn)* are also included in the regression but not tabulated. Panel B repeats the analysis from Panel A with a different definition of past liquidity. *Liquidity*$_{t-1}$ *Qn* is a dummy variable that is equal to one if the liquidity measured in terms of the dependent variable was in the n-th highest quintile in the previous month. *Repurchase dummy x Liquidity*$_{t-1}$ *Qn* denotes an interaction between *Repurchase dummy* and *Liquidity*$_{t-1}$ *Qn*. Liquidity quintiles (*Liquidity*$_{t-1}$ *Qn)* are also included in the regression but not tabulated. Standard errors are clustered at the firm level. t-statistics are provided in parentheses. *, **, *** indicate significance at the 10%, 5% and 1% level respectively.

	Time-weighted spread	Trans.-based spread	Effective spread	Price impact	Amihud
Rep. dummy x TW Spread$_{t-1}$ Q1	0.016***	0.014***	0.010*	0.005	0.032***
	(5.08)	(4.50)	(1.81)	(1.20)	(7.07)
Rep. dummy x TW Spread$_{t-1}$ Q2	–0.008**	–0.005	–0.005	–0.002	–0.000
	(–2.48)	(–1.56)	(–0.91)	(–0.35)	(–0.01)
Rep. dummy x TW Spread$_{t-1}$ Q3	–0.020***	–0.011**	–0.019***	–0.017***	–0.011
	(–4.85)	(–2.54)	(–2.79)	(–2.61)	(–1.33)
Rep. dummy x TW Spread$_{t-1}$ Q4	–0.023***	–0.026***	–0.025***	–0.026***	–0.006
	(–3.87)	(–5.16)	(–3.06)	(–2.97)	(–0.47)
Rep. dummy x TW Spread$_{t-1}$ Q5	–0.027***	–0.017***	–0.012	–0.014	–0.018
	(–3.91)	(–3.28)	(–1.26)	(–1.26)	(–0.81)
R^2	0.766	0.801	0.657	0.597	0.732
Observations	345852	345738	343858	344033	345893
Controls	Yes	Yes	Yes	Yes	Yes
TW Spread$_{t-1}$ Qn Dummies	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes

Table 6: Panel B. Liquidity.

	Time-weighted spread	Trans.-based spread	Effective spread	Price impact	Amihud
Rep. dummy x Liquidity$_{t-1}$ Q1	0.016***	0.007**	0.005	–0.008**	0.037***
	(5.08)	(2.40)	(1.00)	(–2.17)	(7.37)
Rep. dummy x Liquidity$_{t-1}$ Q2	–0.008**	0.000	–0.008*	–0.003	–0.006
	(–2.48)	(0.11)	(–1.66)	(–0.72)	(–1.07)
Rep. dummy x Liquidity$_{t-1}$ Q3	–0.020***	–0.004	–0.011	0.010	–0.005
	(–4.85)	(–0.92)	(–1.62)	(1.58)	(–0.64)
Rep. dummy x Liquidity$_{t-1}$ Q4	–0.023***	–0.007	–0.004	–0.001	–0.000
	(–3.87)	(–1.31)	(–0.50)	(–0.13)	(–0.00)
Rep. dummy x Liquidity$_{t-1}$ Q5	–0.027***	–0.032***	–0.019	–0.034**	–0.053**
	(–3.91)	(–5.28)	(–1.48)	(–2.37)	(–2.36)
R^2	0.766	0.802	0.658	0.598	0.731
Observations	345852	345739	343858	344033	346154
Controls	Yes	Yes	Yes	Yes	Yes
Liquidity$_{t-1}$ Qn Dummies	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes

Table 7: Measuring information using filing-day returns. The table presents regressions of five liquidity measures on a repurchase dummy, cumulative abnormal filing date returns, their interaction, and controls. The appendix provides definitions of the liquidity variables. *Filing CAR (-1,+1)* is the cumulative abnormal return (CAR) of the respective stock from t=-1 to t=+1 relative to the filing day of the 10-Q or 10-K report. The CARs are subsequently matched to the months covered by the report. CARs are computed with the market model using the CRSP equally weighted index. The estimation window ends 31 days prior to the event day. The estimation length is 200 days with a minimum of 100 days being required. All control variables are defined in Table 1.

	Time-weighted spread	Trans.-based spread	Effective spread	Price impact	Amihud
Repurchase dummy	–0.005**	–0.003	–0.005	–0.006**	0.003
	(–2.57)	(–1.39)	(–1.64)	(–2.00)	(0.74)
Filing CAR(-1,+1)	0.011*	–0.002	0.015*	–0.007	0.074***
	(1.74)	(–0.38)	(1.95)	(–0.88)	(4.59)
Rep. dummy x Filing CAR(-1,+1)	–0.075***	–0.058**	–0.070**	–0.065*	–0.171***
	(–3.24)	(–2.36)	(–2.17)	(–1.95)	(–2.82)
R^2	0.768	0.803	0.657	0.597	0.734
Observations	334143	334032	332208	332371	334392
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes

Table 8: Panel A. Measuring information using abnormal returns. The table presents regressions of five liquidity measures on the repurchase dummy, cumulative abnormal returns, their interaction, and control variables. The appendix provides definitions of the liquidity variables. The repurchase variables and the control variables are defined in Table 1. *CAR (1 month)* is the cumulative abnormal return (CAR) of the respective stock in the month after the current month. CARs are computed with the market model using the CRSP equally weighted index. The estimation window ends 6 months prior to the event month. The estimation length is 60 months with a minimum of 36 months. Standard errors are clustered at the firm level. t-statistics are provided in parentheses. *, **, *** indicate significance at the 10%, 5% and 1% level respectively. Panel B repeats the analysis from Panel A with a different measure for abnormal returns. *CAR (6 months)* is the cumulative abnormal return (CAR) of the stock in the subsequent six months.

	(1) Time-weighted spread	(2) Trans.-based spread	(3) Effective spread	(4) Price impact	(5) Amihud
Rep. dummy	–0.003*	–0.003	–0.003	–0.006*	0.011**
	(–1.70)	(–1.44)	(–1.05)	(–1.91)	(2.56)
CAR (1 month)	–0.036***	–0.022***	–0.021***	–0.030***	–0.109***
	(–9.54)	(–6.30)	(–4.43)	(–6.33)	(–10.53)
Rep. dummy x CAR (1 month)	–0.014	–0.039***	–0.076***	–0.064***	–0.042
	(–1.01)	(–2.69)	(–3.74)	(–3.49)	(–1.36)
R^2	0.762	0.805	0.654	0.598	0.732
Observations	291945	291843	290196	290341	292125
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes

Table 8: Panel B. Measuring information using abnormal returns.

	(1) Time-weighted spread	(2) Trans.-based spread	(3) Effective spread	(4) Price impact	(5) Amihud
Rep. dummy	–0.004*	–0.003	–0.004	–0.006**	0.011**
	(–1.75)	(–1.61)	(–1.20)	(–2.04)	(2.41)
CAR (6 months)	–0.016***	–0.017***	–0.010***	–0.023***	–0.040***
	(–8.71)	(–10.53)	(–4.35)	(–10.11)	(–7.89)
Rep. dummy x CAR (6 months)	–0.013**	–0.034***	–0.043***	–0.043***	–0.050***
	(–2.22)	(–5.81)	(–5.38)	(–5.83)	(–3.97)
R^2	0.762	0.805	0.654	0.598	0.732
Observations	291965	291863	290215	290360	292145
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes

Table 9: Unexpected changes in liquidity and stock returns. The table analyzes the stock market performance after repurchases and distinguishes repurchase-months with positive liquidity surprises from repurchase-months with negative liquidity surprises. The appendix provides definitions of the liquidity variables. *CAR (1 month)* is the cumulative abnormal return (CAR) of the respective stock in the month after the current month. *CAR (6 months)* is the CAR of the respective stock over the preceding six months. CARs are computed by applying the market model using the CRSP equally weighted index. The estimation window ends 6 months prior to the event month. The estimation length is 60 months with a minimum of 36 months. We estimate expected liquidity with a regression model as presented in Table 4A, but excluding the repurchase variables. Expected liquidity is set equal to the predicted values of this regression. We identify negative (positive) residuals from this regression with positive (negative) liquidity surprises. We compute average CARs for negative surprises and positive surprises and report mean and median of their differences. We report the two-sample t-test statistic (T-test) and the ranksum test to test whether this difference is significantly different from zero.

	CAR(1,1)	CAR(1,6)
Mean	-0.27%	-1.63%
Median	-0.45%	-1.73%
Standard deviation	9.86%	25.99%
Observations	46,627	46,628
Time Weighted Spread		
Mean(neg. surp. - pos. surp.)	-0.24%	-0.81%
T-test	-2.7	-3.4
Median(neg. surp. - pos. surp.)	-0.08%	-0.18%
Ranksum test (z-stat)	-2.7	-2.3
Transaction Based Spread		
Mean(neg. surp. - pos. surp.)	-0.11%	-0.87%
T-test	-1.2	-3.6
Median(neg. surp. - pos. surp.)	-0.02%	-0.56%
Ranksum test (z-stat)	-1.4	-3.8
Effective Spread		
Mean(neg. surp. - pos. surp.)	-0.16%	-0.85%
T-test	-1.8	-3.5
Median(neg. surp. - pos. surp.)	-0.19%	-0.67%
Ranksum test (z-stat)	-3.6	-4.1
Price Impact		
Mean(neg. surp. - pos. surp.)	-0.23%	-1.10%
T-test	-2.5	-4.5
Median(neg. surp. - pos. surp.)	-0.28%	-1.02%
Ranksum test (z-stat)	-4.6	-5.4
Amihud Illiquidity		
Mean(neg. surp. - pos. surp.)	-0.30%	-1.63%
T-test	-3.3	-5.4
Median(neg. surp. - pos. surp.)	-0.17%	-0.95%
Ranksum test (z-stat)	-3.3	-5.8

Table 10: Volatility, trading volume, and repurchases. The table presents regressions of *Volatility* and *Trading volume (scaled)* on repurchase variables, the lagged dependent variable, and control variables. The repurchase variables and the control variables are defined in Table 1. *RD, RI* and *TV* denote *Repurchase dummy*, *Repurchase intensity,* and *Trading volume* respectively. *RI Qn* is equal to 1 if contemporaneous *Repurchase intensity* is in the n-th quintile. Standard errors are clustered at the firm level. t-statistics are provided in parentheses. *, **, *** indicate significance at the 10%, 5% and 1% level respectively.

	(1) Volatility	(2) Volatility	(3) Volatility	(4) Volatility	(5) Trading volume (scaled)	(6) Trading volume (scaled)	(7) Trading volume (scaled)	(8) Trading volume (scaled)
Volatility$_{t-1}$	0.373***	0.373***	0.373***	0.373***	0.020***	0.020***	0.020***	0.020***
	(117.00)	(116.75)	(117.08)	(116.77)	(3.04)	(3.04)	(3.04)	(3.04)
TV (scaled)$_{t-1}$	0.008*	0.008*	0.008*	0.008*	0.402***	0.402***	0.402***	0.402***
	(1.75)	(1.72)	(1.76)	(1.71)	(10.83)	(10.83)	(10.83)	(10.83)
RD	–0.032***				–0.017***			
	(–9.38)				(–10.41)			
RI	0.422**				0.460***			
	(1.97)				(4.32)			
RD$_{t-1}$		–0.034***				–0.019***		
		(–9.91)				(–11.74)		
RI$_{t-1}$		–0.419**				0.005		
		(–2.16)				(0.07)		
RI Q1			–0.007				–0.011***	
			(–1.35)				(–4.34)	
RI Q2			–0.032***				–0.019***	
			(–6.77)				(–11.18)	
RI Q3			–0.042***				–0.018***	
			(–8.97)				(–10.85)	
RI Q4			–0.040***				–0.016***	
			(–8.42)				(–9.44)	
RI Q5			–0.023***				–0.007***	
			(–4.81)				(–3.77)	
RI Q1$_{t-1}$				–0.021***				–0.014***
				(–4.02)				(–5.95)
RI Q2$_{t-1}$				–0.043***				–0.019***
				(–8.86)				(–11.31)
RI Q3$_{t-1}$				–0.040***				–0.020***
				(–9.01)				(–11.82)
RI Q4$_{t-1}$				–0.041***				–0.021***
				(–8.81)				(–13.13)
RI Q5$_{t-1}$				–0.040***				–0.019***
				(–9.13)				(–12.48)
Constant	–1.748***	–1.747***	–1.749***	–1.748***	0.080**	0.080**	0.080**	0.080**
	(–55.79)	(–55.85)	(–55.82)	(–55.87)	(2.32)	(2.33)	(2.31)	(2.33)
R^2	0.409	0.409	0.409	0.409	0.171	0.171	0.171	0.171
Observations	346107	346830	346107	346830	346114	346114	346114	346114
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 11: Contemporaneous controls. The table presents regressions of five liquidity measures on repurchase variables, and control variables. The appendix provides definitions of the liquidity variables. The repurchase variables and the control variables are defined in Table 1. *Volatility* and *Trading volume (scaled)* enter as contemporaneous variables and not as lags.

	(1) Time-weighted spread	(2) Trans.-based spread	(3) Effective spread	(4) Price impact	(5) Amihud
Repurchase dummy	–0.001	0.002	0.001	0.004	0.019***
	(–0.54)	(0.99)	(0.36)	(1.31)	(5.28)
Repurchase intensity	–0.123	0.236	–0.238	–0.199	1.166***
	(–1.04)	(1.59)	(–1.17)	(–1.15)	(4.48)
Volatility	0.206***	0.157***	0.179***	0.256***	0.741***
	(96.82)	(95.85)	(72.89)	(97.21)	(197.73)
Trading volume	–0.186***	–0.108***	–0.139***	–0.089***	–0.823***
	(–116.05)	(–88.32)	(–81.92)	(–49.47)	(–213.39)
Constant	–0.864***	–0.286***	–0.533***	–0.417***	2.935***
	(–41.17)	(–15.71)	(–19.50)	(–16.23)	(79.43)
R^2	0.805	0.812	0.671	0.620	0.859
Observations	347915	347792	345866	346049	348187
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes

Table 12: Determinants of repurchases. The table presents regressions of repurchases on the time-weighted spread and control variables. The sample is restricted to firms that conduct at least one open market repurchase between 2004 and 2010. Monthly returns are from CRSP. We use the equally weighted CRSP return. The appendix provides definitions of the time-weighted spread. The repurchase variables and the control variables are defined in Table 1. Standard errors are clustered at the firm level. t-statistics are provided in parentheses. *, **, *** indicate significance at the 10%, 5% and 1% level respectively.

	(1)	(2)	(3)	(4)
	Rep. intensity	Rep. intensity	Rep. dummy	Rep. dummy
Time-weighted spread$_{t-1}$	–0.000***	–0.000***	–0.000	0.006**
	(–4.97)	(–2.64)	(–0.05)	(2.22)
Depth ask$_{t-1}$	0.000***	0.000**	–0.000	–0.002
	(3.23)	(2.16)	(–0.08)	(–0.73)
Depth bid$_{t-1}$	0.000***	0.000***	–0.003	–0.003
	(3.85)	(2.98)	(–0.73)	(–0.98)
EBITDA to total assets	0.007***	0.005***	0.495***	0.263***
	(7.52)	(7.38)	(5.98)	(5.52)
Leverage	–0.002***	–0.002***	–0.264***	–0.144***
	(–6.46)	(–6.44)	(–7.40)	(–7.36)
Market cap	–0.000	0.000	0.042***	0.029***
	(–1.41)	(0.11)	(5.24)	(6.63)
Book to market	–0.000**	–0.000**	–0.015**	–0.005
	(–2.33)	(–2.14)	(–2.18)	(–1.35)
Acquiror	–0.000***	–0.000***	–0.036***	–0.021***
	(–6.12)	(–5.78)	(–7.88)	(–6.92)
Target	–0.001***	–0.001***	–0.116***	–0.073***
	(–5.74)	(–4.87)	(–10.56)	(–8.07)
SEO	–0.000**	–0.000	–0.087***	–0.050***
	(–2.02)	(–1.61)	(–10.38)	(–8.21)
Convertible issue	0.007***	0.007***	0.046**	0.075***
	(5.82)	(5.96)	(2.49)	(4.33)
Repurchase intensity$_{t-1}$		0.226***		
		(21.29)		
Repurchase dummy$_{t-1}$				0.463***
				(83.40)

Table 12: Determinants of repurchases. (continued)

	(1)	(2)	(3)	(4)
	Rep. intensity	Rep. intensity	Rep. dummy	Rep. dummy
Monthly Stock Return$_{t-1}$	–0.002***	–0.002***	–0.131***	–0.103***
	(–14.58)	(–14.37)	(–17.14)	(–16.93)
Monthly Stock Return$_{t-2}$	–0.002***	–0.001***	–0.112***	–0.052***
	(–15.90)	(–13.51)	(–16.22)	(–9.89)
Monthly Stock Return$_{t-3}$	–0.001***	–0.001***	–0.071***	–0.018***
	(–9.57)	(–6.07)	(–11.53)	(–3.80)
Monthly Stock Return$_{t-4}$	–0.001***	–0.001***	–0.071***	–0.035***
	(–8.94)	(–6.90)	(–12.17)	(–7.22)
Monthly Stock Return$_{t-5}$	–0.001***	–0.000***	–0.056***	–0.023***
	(–6.87)	(–5.14)	(–10.14)	(–5.09)
Monthly Stock Return$_{t-6}$	–0.000***	–0.000***	–0.042***	–0.015***
	(–5.21)	(–3.76)	(–8.00)	(–3.55)
Monthly Stock Return$_{t-7}$	–0.000***	–0.000***	–0.048***	–0.021***
	(–4.96)	(–3.56)	(–8.83)	(–4.74)
Monthly Stock Return$_{t-8}$	–0.001***	–0.000***	–0.050***	–0.023***
	(–6.50)	(–5.58)	(–9.60)	(–5.49)
Monthly Stock Return$_{t-9}$	–0.000***	–0.000**	–0.033***	–0.009*
	(–3.59)	(–2.18)	(–6.10)	(–1.91)
Monthly Stock Return$_{t-10}$	–0.000**	–0.000	–0.031***	–0.018***
	(–2.38)	(–1.63)	(–5.54)	(–3.98)
Monthly Stock Return$_{t-11}$	–0.000***	–0.000***	–0.027***	–0.014***
	(–4.14)	(–3.74)	(–5.13)	(–3.14)
Monthly Stock Return$_{t-12}$	0.000	0.000	–0.006	0.004
	(0.71)	(1.54)	(–1.20)	(0.96)
Monthly CRSP Return$_{t-1}$	–0.003***	–0.002***	–0.228***	–0.129***
	(–9.67)	(–7.68)	(–11.99)	(–7.58)
Monthly CRSP Return$_{t-2}$	0.001***	0.002***	0.074***	0.174***
	(4.01)	(6.88)	(4.68)	(10.98)
Monthly CRSP Return$_{t-3}$	–0.000	–0.000	–0.060***	–0.038***
	(–1.43)	(–1.29)	(–3.89)	(–2.69)
Constant	0.000	0.000	0.105*	0.062*
	(0.59)	(0.92)	(1.81)	(1.95)
R^2	0.021	0.071	0.033	0.240
Observations	191254	190748	191297	190823
Firm FE	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes