On the Timing and Execution of Open Market Repurchases

Douglas O. Cook
University of Mississippi

Laurie Krigman
Babson College

J. Chris Leach
University of Colorado and Stockholm Institute for Financial Research

Little is known about the timing and execution of open market repurchases. U.S. firms are under no obligation to disclose when they are trading, and generally report only quarterly changes in shares outstanding. We use 64 firms' supplementally disclosed repurchase trading data to provide the first examination of repurchase timing and execution. Across the days reported in our sample, firms adopted a variety of execution styles ranging from immediate intense repurchasing to delayed and smoothed repurchasing. We find no clear evidence that repurchases are timed to coincide with, precede, or follow, days on which information is released. We benchmark the costs and value of a given repurchase program against naive accumulation strategies achieving the same terminal portfolio. While there is considerable variation across the firms, NYSE firms on average beat their benchmarks, whereas NASDAQ firms do not. Finally, we document the liquidity impact of open market repurchases. We find that repurchasing contributes to market liquidity by narrowing bid-ask spreads and attenuating the price impact of order imbalances on days when repurchase trades are completed.

Announcements of open market repurchase programs in the United States have grown dramatically, from 131 companies' repurchasing $15.8 billion in 1985 to 1038 companies' announcing repurchases valued at $147.8 billion in 2001. The importance of stock repurchases as a method of returning capital to shareholders is well established. Previous research has extensively analyzed the volume of repurchase activity, the information content of repurchase announcements, and the long-term performance of repurchasing firms [see, e.g., Ikenberry, Lakonishok, and

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Vermaelen (1995), Ikenberry and Vermaelen (1996), Stephens and Weisbach (1998), and Jagannathan, Stephens, and Weisbach (2000)]. Little is known, however, about how firms implement open market repurchase programs or the impact they have on market liquidity. This lack of knowledge stems from the fact that U.S. repurchase execution data are difficult to obtain. Current disclosure standards, as regulated by the FASB and the Securities and Exchange Commission (SEC), impose no obligation on firms to disclose repurchase details beyond the number of shares outstanding at quarter-end.[1] Quarterly 10Q and annual 10K filings provide the only indication of repurchase activity. Consequently, little is known about repurchase trading. This article provides the first in-depth examination of U.S. repurchase trading behavior. Using voluntarily disclosed data, we examine the timing and market impact of 64 firms' repurchase programs during 1993 and 1994.

Given that a firm has decided to initiate a repurchase program, the choice of how and when to trade can be motivated by different goals and have different empirical implications. The most frequently cited reason for initiating an open market repurchase program is that a firm thinks its stock is undervalued and is therefore a good investment. We take the long-term repurchase motivation as given and examine short-term motives for the daily repurchase decision. Essentially we ask the question: Why does a firm repurchase on one day and not on another? The short-term repurchasing motives we consider include cost minimization, price support, liquidity provision, and the strategic use of firm-specific information.

For the cost-minimizing repurchaser, the choice of when to repurchase may simply be driven by stock price, without concern for alternative impacts such as increased liquidity or price support. As repurchasing firms can only buy shares in the open market (and not resell them), they face an optimal accumulation problem rather than the more widely analyzed traditional market timing problem. To evaluate the success of their accumulation strategies, we compare the cost of the realized repurchase portfolio with several naive accumulation strategies. We find mixed results. The larger firms in our sample [New York Stock Exchange (NYSE)-listed] generally perform very well from a cost-minimization perspective. On the other hand, smaller firms tend to pay relatively high prices for their shares.

Open market repurchase trading can also be used to support a falling stock price by absorbing sell-side pressure. For the corporation motivated by a desire to support its market price, we expect that much of its repurchasing will be done through limit orders which are hit in falling

[1] Although the SEC provides safe harbor rule 10b-18 to protect repurchasing firms from charges of market manipulation, the regulation does not mandate specific disclosure. See Cook, Krigman, and Leach (2003) for an examination of repurchasing firms' use of rule 10b-18.

markets. Consistent with successful price support, we find widespread buying at the bid on the NYSE. We document that firms repurchase following price drops and that prices stabilize following repurchase trades.

If firms are motivated by a desire to provide liquidity (and potentially reduce their cost of capital), it is reasonable to ask whether open market repurchase trading has a detectable impact on alternative measures of liquidity. One way that a firm might directly affect the quoted spread is by placing a buy limit order. An exposed repurchase limit order can directly raise the bid and thereby reduce the quoted spread. Somewhat less directly, the knowledge that the corporation is buying, perhaps without a formal limit order, can provide sufficient incentive for market makers to increase the bid or provide more quoted depth at the current bid.[2] In either case, we should detect increases in sell-side liquidity.

There is a sizable literature on the liquidity effects of open market repurchase program announcements. Barclay and Smith (1998), Singh, Zaman, and Krishnamurthi (1994), and Miller and McConnell (1995) each examine changes in the bid-ask spread surrounding open market repurchase announcements and find mixed results. These studies focus on liquidity as the explicit cost of transacting, measured by the quoted bid-ask spread. We extend this literature by analyzing days of actual repurchase trading as opposed to announcement effects. We compare days when repurchase trades are executed to surrounding nonrepurchase days. Consistent with repurchase trading contributing to market liquidity, we document that quoted spreads are narrower on repurchase days than on the days immediately preceding and following a repurchase. In addition, for National Association of Securities Dealers Automated Quotation (NASDAQ) stocks, spreads narrow dramatically, by more than 11 cents per share, compared to a prerepurchase announcement trading period.

Liquidity is also related to the price impact of executing a trade. For example, Kyle (1985) defines liquidity as the order flow needed to move prices one unit, and O'Hara (1995) defines a liquid market as one that accommodates trading with the least effect on price. We examine whether liquidity, as measured by the order flow price change relationship, is different when corporations are actively repurchasing stock. Consistent with repurchase-related increased liquidity, we find a lower price impact for order imbalances on repurchase days than on nonrepurchase days. Repurchase trading appears to absorb sell-side order imbalances. Thus from two liquidity perspectives, changes in quoted spreads and the price impact of trades, we document evidence that repurchase trading does not detract from market liquidity and appears to be a net contributor.

[2] In 1993 and 1994, the depth field in the NYSE Transactions and Quotations (TAQ) database provided limited information. Therefore we are unable to directly examine the impact on the depth of the market.

The final, and perhaps most controversial, repurchase motivation we consider is whether the repurchasing firm is motivated by the opportunity to profit from proprietary firm-specific information. Ikenberry, Lakonishok, and Vermaelen (2000) examine the monthly repurchase timing for a set of Canadian firms and find that repurchase activity is linked to price movements. We take their analysis one step further and examine the daily repurchase decision as it relates to past and future price and market movements. We find evidence that firms repurchase following days when prices have fallen, but find no clear evidence that they are able to trade in advance of price increases. In addition, we find that firms significantly curtail repurchasing in the five-day window centered on firm-specific announcements. Thus trading on proprietary information is not evident in our sample.[3]

Of course, none of the motivations we consider for stock repurchasing are mutually exclusive. The firm's actual motivation could be a combination of any or all of the motivations we consider. In addition, empirically it is difficult to distinguish among the different motivations. For example, price support and liquidity provision motivations can both be accomplished by buying at the bid. Consequently, we cannot easily tell whether liquidity provision is a direct objective for the repurchasing program or an indirect benefit of a price support strategy.

The study most closely related to ours is Brockman and Chung (2001). They examine the timing and liquidity impact of open market repurchases in Hong Kong. One interesting feature of the Hong Kong study is the disclosure environment. Repurchasing firms in Hong Kong must publicly disclose all repurchase transaction details by the start of trading on the day following a repurchase trade. This stands in stark contrast to the environment of nondisclosure in the United States. Generally, in the United States, a firm is silent on its repurchase activity following the announcement of a program. Thus knowledge that an informed trader is in the market is not as straightforward as in Hong Kong. We find significantly different U.S. trading behavior and a distinctly different market impact for repurchases than that documented by Brockman and Chung for Hong Kong repurchasing. They find that repurchases have a detrimental effect on liquidity. They find wider bid-ask spreads and narrower depths during repurchase trading, evidence consistent with a negative response to the presence of informed managerial trading. We find that U.S. repurchase trading appears to contribute to market liquidity. We document narrower bid-ask spreads and less price movement during periods of order imbalance on U.S. repurchase trading days. Thus the disclosure environment appears to play an important role in the behavior and impact of repurchase trading.

[3] Given that our dataset has been voluntarily disclosed, this result is not surprising.

The main results we present are

- Repurchase programs vary widely across firms. That is, program length, speed of completion, and timing vary widely in our sample. For example, one firm completed its announced program on one trading day, while another repurchased on 288 of 387 trading days following the program's announcement.
- We find evidence that firms decrease repurchasing activity around firm-specific information announcements. Thus they appear to take care to avoid trading on short-term information.
- We find that many firms repurchase following price drops. On the NYSE, daily repurchase volume is related to contemporaneous and lagged price changes and trading volumes. NASDAQ firms' repurchase volumes are unrelated to both lagged excess return measures and contemporaneous price changes.
- Trade execution appears to be influenced by market structure (specifically, the use of limit orders) and firm size. On the NYSE, 38.9% of repurchase trades are executed at the prevailing market bid, consistent with the use of a limit order. On the NASDAQ, only 8.1% of trades are similarly executed.
- We show that repurchase trading contributes to market liquidity through narrower bid-ask spreads on repurchase days than on adjacent nonrepurchase days, and that order imbalances move prices less when repurchasing firms are active in the market.
- From a cost perspective, we find that NYSE firms pay significantly less compared to several *naive* accumulation strategies. In contrast, NASDAQ firms pay more compared to these same strategies.

The remainder of the article is as follows. Section 1 describes the solicitation and construction of our repurchase dataset. Section 2 provides a detailed description of several programs in our sample. Section 3 documents daily and intradaily repurchase patterns. Section 4 provides an analysis of the daily decision to repurchase shares. Section 5 examines the liquidity aspects of repurchase programs. Section 6 discusses the methods and benchmarks we use to measure timing ability within the repurchase period. Section 7 offers concluding remarks.

1. The Repurchase Dataset

Data on the details of repurchase execution are not readily available. We directly solicited repurchase data from the 478 firms identified in the Securities Data Company's (SDC) Mergers and Acquisitions Database as announcing open market repurchase programs between March 10, 1993, and March 4, 1994. Appendix A provides a copy of the questionnaire we sent to the 478 firms. Sixty-eight firms responded to our request.

Four of the 68 indicated that they were unable, or unwilling, to provide the requested data. The remaining 64 firms constitute the sample used in our study.[4] One firm changed its listing from the NASDAQ to the NYSE during its repurchase program and consequently our final sample includes 24 NYSE programs and 41 NASDAQ programs.

Firms provided the target dollar amount of the program or the target number of shares, the program status (complete or ongoing), the agent designated to coordinate the repurchase activity, and the name of a contact person. The disclosed trading data included the trading dates, the exchange used, the number of shares acquired, the price paid per share, and an indication of whether the prices were exact or a daily average. We undertook several checks to ensure the accuracy of the response data. Initially we checked the reported volume against total daily volumes from the NYSE Transactions and Quotations (TAQ) dataset. We contacted the corporations for clarification when we encountered infeasible trades.[5] Our final dataset includes 84.2 million shares traded on 2190 firm-trade days for 64 firms in 1993 and 1994.

In order to examine trade execution location and within-day repurchase timing, transaction-level repurchase data are necessary. Most firms in our sample provided total shares repurchased and an average price for each trading day. Some firms provided more detail, such as daily volume repurchased at each trading price. We use combinatorial programming across the entire sample to identify repurchase transactions from the NYSE TAQ database. We provide details of the combinatorial procedure in Appendix B. Of the 3585 reported repurchases across 64 firms and 2190 firm-days, we locate 2655 repurchase trades on 1431 firm-days representing more than 31 million shares. This is the sample used in our analysis of within-day timing.

Overall our sample represents a wide cross section of the market. The 1993 average daily trading volume ranges from 32,500 shares to more than 95 million shares, with an average of 12.6 million shares. The market capitalization ranges from \$6 million to more than \$31 billion. The percent of the total daily volume acquired in one day ranges from .03% to 100%.[6] The percent of outstanding shares targeted ranges from .56% to 32.8%, with an average of 7%. The trading frequency varies widely across

[4] Many of the participating corporations provided their repurchase data with the understanding that their participation in the study would be confidential.

[5] The most common inconsistencies were due to reporting settlement rather than execution dates, and including brokerage commissions in the price. We exclude eight transactions from six firms which were not feasible and no resolution was found, 42 reported repurchase days in 1992 (due to the absence of TAQ data), and eight trades reported as private transactions.

[6] SEC rule 10b-18 restricts nonblock repurchase volume to 25% of the average daily trading volume during the four calendar weeks prior to the week of a repurchase. In addition, it is a safe harbor, not a requirement. Thus there is no prohibition on taking 100% of a day's total trading volume.

firms. One firm repurchased their announced program target on one day (a very small program), whereas another firm repurchased on 288 of 387 consecutive trading days. Firms waited an average of 17 days following the announcement of a repurchase to make their first trade. One firm waited 124 days, more than four months, from the announcement of the repurchase program to begin repurchasing.

If firms are repurchasing with a liquidity provision or price support motive, the structure of equity trading can affect whether a program can meet its objective. Specifically, how and when firms repurchase may depend on the exchange where a firm's stock is listed; a specialist system such as the NYSE may afford different opportunities for the firm than the dealer structure used on the NASDAQ. On the NYSE, limit orders compete with the specialist and can directly influence the quoted bid-ask spread and provide an effective vehicle for providing price support. During the time of our study, however, NASDAQ market makers were under no obligation to display limit orders they received. As such, the NASDAQ operated as a pure dealer market, with the public unable to compete directly with market makers to directly effect a narrowing of the quoted spread. The absence of a NASDAQ guarantee that a limit order will be displayed limits their usefulness as a mechanism for liquidity provision and price support.[7]

When we consider how much of a day's volume a firm repurchases, trading protocol may also influence repurchase costs. For example, due to dealer-to-dealer trading on the NASDAQ, reported trading volume is overstated relative to NYSE volume. Accordingly, the percent of daily trading volume repurchased is understated (relative to NYSE). To allow for potential microstructure effects, we segregate our sample by exchange listing.[8]

Table 1 provides summary statistics partitioned by exchange listing. As might be expected, (i) NYSE-listed firms are significantly larger than the NASDAQ firms; (ii) NYSE firms repurchase on more days; and (iii) NYSE firms repurchase more shares in total. However, there is no difference in the relative size of the programs as measured by the target percent of outstanding shares sought for repurchasing. Of interest is that the NASDAQ firms take a significantly larger share of the day's trading volume on days they do repurchase.

[7] Repurchases can affect market liquidity through increased trading depth even without the requirement that repurchase limit orders be displayed. Repurchase trading represents a significant portion of daily volume in our sample (especially on the NASDAQ). This assurance of greater trading depth may prompt market makers to change their quotes, an indirect effect, rather than a direct effect from displaying the limit order. Thus even unexposed limit orders may be useful to the repurchasing NASDAQ firms.

[8] A few firms in our sample indicated in their responses that trading structure is a relevant consideration when repurchasing.

Table 1
Summary data

	NYSE		NASDAQ		
	Mean	Median	Mean	Median	*p*-value
Days of successful repurchase up to response date	87.9	56.0	16.2	11.0	[0.0001]
Market capitalization ($000) year end 1993	6,688,997	2,444,163	222,401	81,066	[0.0001]
Trading volume (000) shares cumulative 1993	6,520,179	3,076,400	1,345,914	748,115	[0.0001]
Program shares repurchased up to response date	40,700,400	19,871,400	4,649,497	2,094,000	[0.0001]
Repurchase Shares as a percentage of daily volume	19.48%	13.50%	33.03%	31.20%	[0.0001]
Target shares as a percentage of shares outstanding	7.40%	3.99%	6.90%	5.16%	[0.7734]
Reported shares repurchased to response date as percentage of shares outstanding	1.50%	0.67%	3.31%	2.82%	[0.0118]
Days from announcement to first reported trade[a]	12.2	8.5	18.8	9.0	[0.3449]

[a]Calculated for the 50 firms for which an announcement was available and for which there was no evidence of an existing repurchase program.

Summary statistics for the 64 firms (23 NYSE and 41 NASDAQ) executing repurchase programs, including firm size and trading activity, size of repurchase program, length of time to complete, and time from announcement to the first corporate trade are presented. The *p*-value from a Student's *t*-test under the null hypothesis that the NYSE firms are equal to the NASDAQ firms is provided.

1.1 Potential survey nonresponse bias

Gathering data through survey introduces a potential self-selection bias in firms that choose to respond. There are at least two reasons why a firm might not wish to have its repurchase record revealed. First, if a firm is successful in using information to its advantage while repurchasing, accusations of manipulation or fraud may arise. For this reason, it may be difficult to detect repurchase-related excess trading profits in the records of our responding firms. On the other hand, if a firm loses money on its repurchase program, paying too much for its shares or consistently buying at the worst possible times, it may likewise choose not to respond to our survey. Consequently our dataset most likely contains firms that do not perform too well or too poorly, and our findings are likely attenuated relative to nonresponding firms.

We investigate the potential nonresponse bias using two types of data. First, we examine firm-level characteristics of responding and nonresponding firms. Second, to address potential performance-related reasons for a firm's not wishing to have its repurchase record revealed, we examine market-based return data. Table 2 provides details.

The responding firms have a significantly larger mean market value of equity compared to nonrespondents ($2646 million versus $781 million). However, the data are highly skewed. Nonparametric tests reveal no

Table 2
Survey response statistics

	Responding firms		Nonresponding firms	
	Number	Percent	Number	Percent
Number of firms	64		390	
Exchange listing:				
NYSE	24	37.5%	174	44.6%
NASDAQ	41	64.1%	193	49.5%
AMEX	0	0.0%	23	5.9%

	Responding firms		Nonresponding firms			
	Mean	Median	Mean	Median	*t*-statistic	Ranked sums
Market value of equity ($000)	2,646,276	263,475	781,280	261,055	2.29 [0.0256]	0.12 [0.9014]
1993 annual trading volume (million shares)	3,256	1,287	38,576	12,377	−8.78 [0.0001]	−9.05 [0.0001]
Targeted shares as a percentage of shares outstanding	6.90%	5.01%	6.97%	5.08%	0.08 [0.9369]	−0.18 [0.8534]
CAR at announcement	2.94%	2.35%	2.23%	1.85%	0.73 [0.4664]	2.04 [0.7777]
3-year size-adjusted return	39.57%	29.48%	40.29%	29.11%	−0.05 [0.9574]	−3.21 [0.6550]
3-year market-adjusted return	18.07%	4.71%	19.31%	5.98%	−0.11 [0.9112]	2.45 [0.7333]

Summary statistics are provided for the 64 firms that complied with our solicitation for data and for 390 of 414 firms that chose to ignore our solicitation for which we could locate data. The table contains information on exchange listing, firm size, annual trading volume, and announced repurchase program size as a percent of shares outstanding. We also provide the cumulative abnormal return over the announcement period days 0 to +1, and a size-adjusted and value-weighted excess return for the three years after announcement. Parametric and nonparametric tests are provided that compare responding to nonresponding firms.

apparent difference in median firm size. Program size, expressed as a percentage of outstanding shares, is similar (6.9%) for responding and nonresponding firms. The response count for NASDAQ firms (41 firms or 17.5% of those solicited) is higher than that for NYSE firms (24 firms or 12.1% of those solicited). The higher percentage of responding NASDAQ firms helps to explain the lower annual trading volume we report for our sample of responding firms relative to the nonresponding firms.

We examine cumulative abnormal returns surrounding the program announcements and for three years following the program announcement for the full set of firms announcing open market repurchase programs during 1993 and 1994. Cumulative abnormal returns at the announcement are measured for two days (0, +1) using a market model. Market model parameters are estimated over the period −100 to −11. Three-year abnormal returns are measured in two ways. First, we calculate market-adjusted holding period returns relative to the Center for Research in Security Prices (CRSP) value-weighted index. Second, following Lyon, Barber, and Tsai (1999), we calculate holding period size-adjusted returns relative

to NYSE size portfolio deciles. Consistent with Ikenberry, Lakonishok, and Vermaelen (1995), we find positive abnormal returns at the announcement and for the three years after announcement. Importantly, we find no difference in returns between the responding and the nonresponding firms. Overall, while our sample is small, on these limited dimensions it appears representative of open market repurchase programs in general during the period we study.

The use of survey data can always be subject to criticism, even when the survey data are verifiable (as with repurchase trades). However, we feel that it is important to weigh the potential gain in our understanding of issues not currently addressable with publicly available datasets against any possible overgeneralizations fostered by potential self-selection bias. Without an SEC- or FASB-directed change in repurchase disclosure requirements, survey is the only technique available for examining the timing and implementation of U.S. repurchase programs. Ultimately the possibility of self-selection bias remains and all results should be interpreted with this in mind.

2. Characterizing Repurchase Trading

The level of detail in our repurchase sample permits an examination of questions not previously addressed. Do firms repurchase an equal number of shares on a daily basis throughout a program? Do they repurchase in proportion to market volume? Is the choice of repurchase day related to price movement or general market activity? Do firms time their trades with respect to either information releases or inside information? The firms in our sample exhibit great diversity in trading execution. Therefore, prior to treating our sample as observations from a homogeneous population, we provide a detailed characterization of four different programs that highlight the heterogeneity in our sample. Figure 1 displays the daily repurchase volume of the four firms across time.

- **Firm 1** announced an intent to repurchase 2,100,000 shares in the open market. It waited 2 days and then repurchased 225,000 shares over the following 6 days, after which it did not successfully repurchase for the next 59 trading days.[9] The firm then repurchased 1,000,000 shares over 13 of the next 16 trading days. It did not repurchase for the following 25 trading days and achieved its stated target by buying 875,000 shares over the subsequent 9 trading days. Over the duration of the program, the firm repurchased between 5000 and 191,700 shares per day.

[9] As we have data only on successful repurchase executions, we cannot say whether firms were active in the market, say with limit orders, even though not in a way that resulted in actual repurchase.

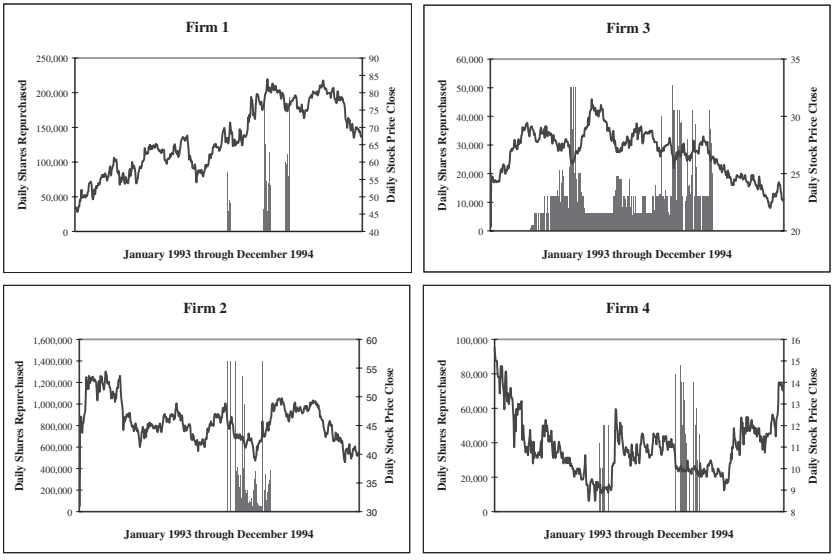

Figure 1
Price support, random trading, or timing skill? Daily closing stock price and shares repurchased are presented for four representative firms over the period January 1993 through December 1994.

- **Firm 2** announced an intent to repurchase up to $500 million of its common stock in the open market. It waited 10 trade days to enter the market and then executed repurchases on 45 of the following 47 trade days, averaging 210,980 shares per day, and ranging from 50,000 to 1,258,000 shares per day. Two days after this buying period, the firm released an earnings announcement stating "better than expected first quarter results." On the fifth day following this announcement, the firm resumed repurchasing. It completed its stated target in the next 11 trading days, with an average repurchase of 208,590 shares per day.
- **Firm 3** announced an intent to purchase common stock with aggregate market value of up to $50 million. The firm waited five weeks to enter the market. After repurchasing 513,800 shares over 25 weeks, the firm announced a continuation of the repurchase program (for an additional $50 million). Over the entire 65-week period of our analysis, the firm purchased a total of 3.6 million shares valued at $100,000,000 including commissions on 288 of 325 trade days. Daily shares repurchased ranged from 100 to 50,000 with a mode of 6000 shares per day. The firm's repurchase behavior does not appear to change for information releases. It also appears unrelated to changes in nonrepurchase trading volume.
- **Firm 4** announced an intent to repurchase up to $25 million of common stock. It waited two days to begin repurchasing. The firm

bought 300,000 shares on 9 of the following 18 trade days. After 24 weeks without a repurchase, it bought 930,000 shares over 18 of 45 trading days. There appears to be some relationship between the firm's repurchasing behavior and stock prices during the repurchase period. For example, prior to the announced repurchase, the stock fell from a high of \$15.625 to \$8.75. The firm bought shares in the range of \$8.75 to \$9 per share and stopped buying as the stock price began rising. During the 24-week window when the firm did not trade, the stock traded in the \$12 range. When the price fell to \$9 per share, the firm reentered the market for more repurchases. Following the last reported repurchase, the stock was trading in the \$13 range.

The diversity of these examples suggests that general statements about repurchase program execution can be misleading. By design, any statistical analysis will deemphasize the diversity of styles and objectives of repurchasing firms.

3. Frequency and Timing of Repurchase Trading

The first question we address is, 'When do firms repurchase and do they represent a significant presence in the market?' Table 3 provides descriptive statistics on the daily timing of repurchases. The average program

Table 3
Repurchase activity

	NYSE firms		NASDAQ firms	
	Mean	Median	Mean	Median
Program length	195.0	205.0	116.0	85.0
Repurchase days	87.9	56.0	16.2	11.0
Percent of aggregate volume	6.6%	3.9%	10.4%	7.9%

	NYSE firms percent of daily volume			NASDAQ firms percent of daily volume		
	Days	Mean	Median	Days	Mean	Median
All days	1577	19.48%	13.50%	613	33.03%	31.20%
Monday	295	19.69%	14.74%	116	33.14%	32.51%
Tuesday	328	19.25%	12.97%	120	33.41%	31.67%
Wednesday	328	20.15%	13.50%	114	33.04%	31.59%
Thursday	319	19.55%	13.92%	131	33.39%	28.38%
Friday	307	18.75%	11.95%	132	32.24%	31.89%

Trading statistics are presented for the 2190 repurchase days in the sample. In the top panel of the table, we include the mean and median length of the repurchase program, the number of days repurchase trades were executed, and the percent of aggregate volume, defined as the percentage of total trading volume over the course of the entire repurchase program that represents repurchased shares. The bottom panel provides trading activity by the day of the week. We include the number of trade days, and the mean and median percent of daily volume, defined as the percentage of each day's total trading volume that represents repurchased shares. Data are partitioned by exchange listing.

length for 24 NYSE programs is 195 days, with 88 days of repurchasing. Repurchases account for an average of 19.5% of trading volume on the days firms complete trades. In all, the NYSE firms repurchased 70.2 million shares, representing 6.6% of aggregate trading volume executed over the course of the entire repurchase program. On the NASDAQ, repurchase trading accounts for 33% of a repurchase day's reported trading volume. NASDAQ firms, however, only repurchased on an average of 16 of 116 reported days. The total reported repurchase volume of 14.6 million shares represents 10.4% of aggregate trading volume reported over the entire repurchase program. That is, about 1 in every 10 shares traded during the repurchase period is a repurchase. Overall, trading on an NYSE repurchase day is more likely (than trading on a NASDAQ repurchase day), although within such a day meeting an NYSE firm as a counterparty is less likely (than meeting a NASDAQ firm as a counterparty).

We also examine trading by the day of the week. Gibbons and Hess (1981), among others, document that Mondays have lower returns than other days of the week. Lakonishok and Maberly (1990) demonstrate that while institutions are less likely to trade on Mondays, individuals are more likely to sell than buy on Mondays. Thus they find an imbalance between buy and sell transactions which results in slightly lower stock prices on Mondays. A cost-minimization objective would suggest increased repurchase activity on Mondays relative to other days of the week. However, consistent with lower institutional trading on Mondays, the NYSE firms in our sample trade slightly less frequently on Mondays than on other days (295 of 1577 trade days, or 18.7% of the time repurchases occur on Monday). On the NASDAQ, we find that firms appear to trade slightly more on Thursdays and Fridays than on other days of the week. Overall we do not find evidence that repurchasing firms increase buying activity on Mondays to take advantage of order imbalances and lower stock prices.

Within a trading day, previous research has documented U-shaped patterns in bid-ask spreads and trading volume [see, e.g., Jain and Joh (1988) and Chan, Christie, and Schultz (1995)]. We partition each day into 30-minute intervals and examine repurchase activity within the day. Panel A of Figure 2 presents half-hourly shares repurchased as a percent of total shares repurchased. Thus it provides an indication of preferred trading times for repurchasing shares. NYSE firms executed more than 15% of their repurchases in the first half hour of trading. In fact, 26.3% of all repurchases on the NYSE take place in the first hour of trading for the day. On the NASDAQ, only 15% of repurchases are executed in the opening hour and 25% take place in the final hour of trading. Panel B of Figure 2 presents half-hourly repurchase volume as a percent of total trading volume during the half hour. On the NYSE, firms appear to be

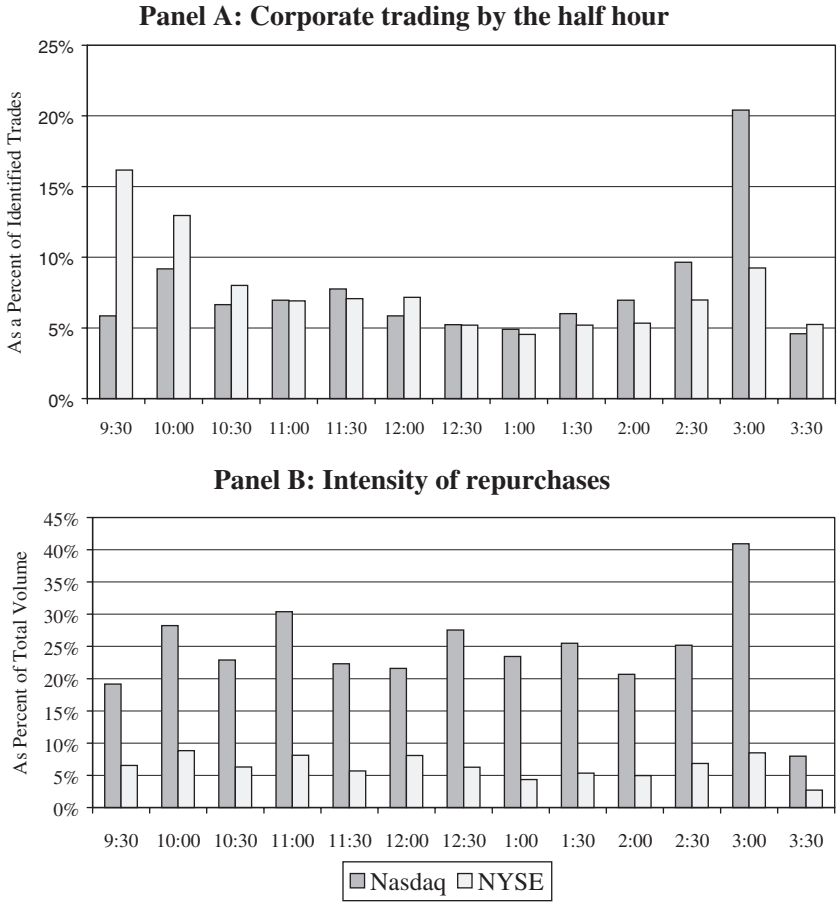

Figure 2
Identified repurchase shares are presented for NASDAQ and NYSE firms partitioned by trading time. Trading is broken down into half-hour intervals. In panel A, we present shares repurchased during the half-hour window as a percentage of total shares repurchased. In panel B, repurchases are displayed as a percentage of total trading volume during the half-hour window.

consistent with other traders in their buying volume throughout the day, taking roughly 5% of the trading volume each half hour. On the NASDAQ, however, buying intensity spikes in the late afternoon, where repurchases account for more than 40% of trading volume.

Figure 3 presents NYSE and NASDAQ total daily volume for repurchase and all other trades over the course of the trade day. On the NYSE, trading levels display the familiar U-shaped patterns: volume is higher in the morning and late afternoon than during the middle of the day. One exception to the pattern is the low level of repurchase activity in the closing half hour of trading. This is consistent with some firms' following

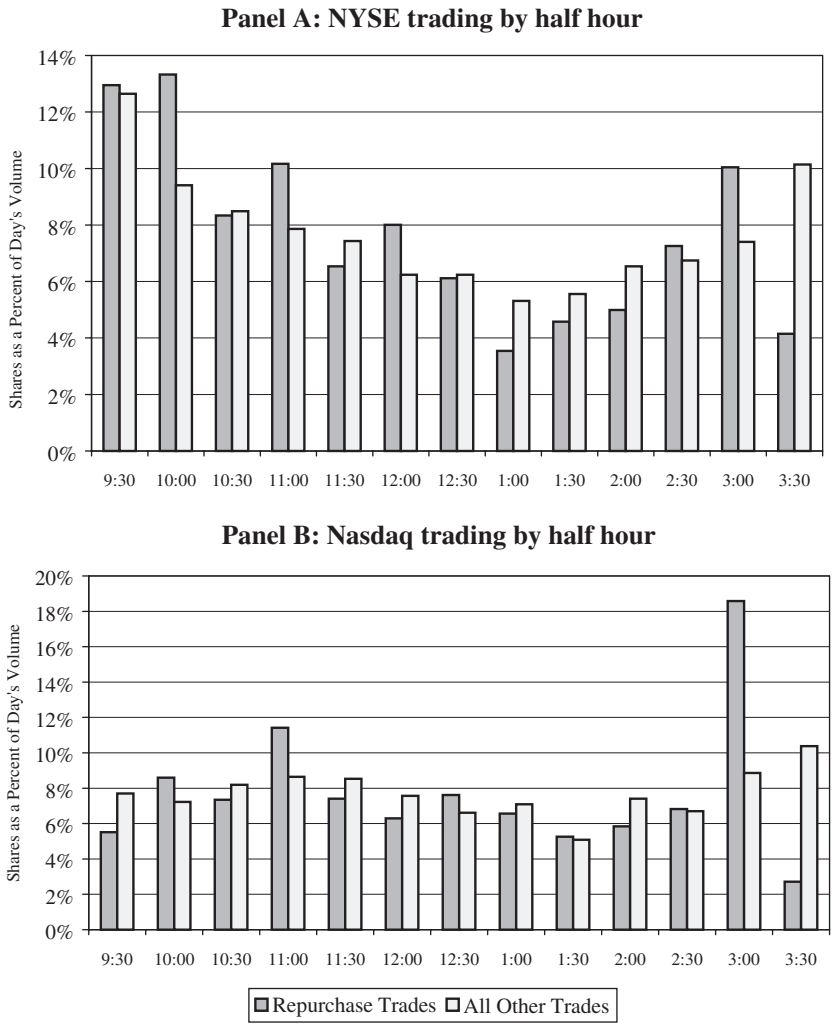

Figure 3
Identified repurchase shares and noncorporate trading volume (which includes unidentified repurchase shares) are presented for NASDAQ and NYSE firms separately. We partition each day into 13 half-hour windows and present half-hourly trading volume as a percentage of total trading volume for the day.

part of the SEC's voluntary safe harbor rule 10b-18.[10] While others have documented U-shaped volume patterns on the NASDAQ, the NASDAQ firms in our sample do not appear to exhibit such a pattern. Nonrepurchase volume (which includes unidentified repurchases) is roughly constant over the course of the day and increases slightly at the close. Repurchase

[10] One provision of rule 10b-18 precludes repurchasing in the last 30 minutes of the day.

activity exhibits a dramatic increase between 3:00 and 3:30 PM, nearly tripling relative to the rest of the trade day, before dropping to only 2% during the final half hour of trading.

While these initial patterns suggest some regularities in repurchase timing, in order to focus on repurchase motivations, we examine in more detail when firms buy. In particular, our dataset allows us to examine whether firms follow the market and hide amongst liquidity traders, whether they provide additional liquidity by buying when others are not, or whether they step in during falling markets to support the market price. As liquidity provision and price support are not typically listed among firms' reasons for establishing a repurchase program, we first consider more generally the possible stimuli that prompt a firm to trade.

4. The Repurchase Decision

The choice of how many shares to repurchase on a given day and when to repurchase them can be driven by many factors. As can be seen in Figure 1, firms do not trade uniformly through time. In this section we take a two-step approach. First, we focus on factors that may encourage a firm to transact at various levels on a given day. We estimate a model of daily repurchase volume that considers recent and future market conditions (assuming insider foresight), contemporaneous nonrepurchase trading, the level of program completion, and firm announcement timing. Second, to examine more directly the evidence that would be consistent with price support or liquidity provision, we examine repurchase timing within the trade day.

Ikenberry, Lakonishok, and Vermaelan (2000) document that firms increase repurchasing in months following price drops for a set of Canadian firms. Stephens and Weisbach (1998) examine quarterly repurchase volume in the United States and find that it is negatively related to prior returns and is positively related to both expected and unexpected cash flows. Our investigation examines the daily decision to repurchase as it relates to past and future price drops and overall market movements. If a firm is interested in a cost-minimization strategy, recent stock price movements could contribute to the choice of trade day. For example, when there is evidence of mean reversion in price, a naive cost-minimization strategy would involve buying more shares following price declines. In contrast, if a firm is using inside information to time their trades, we would expect increased buying following price drops *and* preceding price increases. We would also expect trading levels to vary systematically around the release of firm-specific information. When liquidity provision or price support are contributing motivations, in addition to increased repurchasing during or soon after price decreases, we would expect repurchasing to be correlated with market conditions such

as nonrepurchase trading volume and order imbalances. Specifically we would expect increased repurchase activity during periods of low trading volume or sell pressure.[11] In contrast, if a repurchasing firm is interested in hiding among existing liquidity rather than increasing it, the firm may be more aggressive in repurchasing when nonrepurchase trading volume is higher.

In an attempt to determine whether firms are strategically repurchasing, we estimate a Tobit model of the daily repurchase decision. We focus on the raw number of shares repurchased on each day because this is the decision variable for a person implementing a repurchase program. In addition, examination of the plots in Figure 1 reveals that some firms buy a fixed number of shares on a daily basis and deviate from this level sporadically.

The independent variables we consider as potential motivating factors for a firm to execute a repurchase include contemporaneous, lead and lagged market, and firm-specific variables. Specifically, we include the contemporaneous market return proxied by the daily return on the S&P 500 (R_t^M); the excess stock return ($XR_{i,t}$), defined as the stock return less the contemporaneous return on the S&P 500; lead and lag cumulative abnormal returns (CAR);[12] nonrepurchase trading volume ($V_{i,t}^{NR}$); the percent of the program completed to date ($C_{i,t}$); and an indicator variable set to one if the firm made any news announcement on the day ($A_{i,t}$) or in the two days leading up to or following the announcement ($A_{i,t\pm2}$).

We estimate the following Tobit model of the daily repurchase intensity:

$$V_{i,t}^R = \beta_1 + \beta_2 R_t^M + \beta_3 XR_{i,t} + \beta_4 CAR_{i,t-k,t-1} + \beta_5 CAR_{i,t+1,t+k} + \beta_6 V_{i,t}^{NR} + \beta_7 C_{i,t} + \beta_8 A_{i,t} + \beta_9 A_{i,t\pm2} + \epsilon_{i,t}.$$

We estimate the model separately for each firm using the complete time series of trade days starting 10 trade days prior to the first reported repurchase through 10 trade days following the last reported repurchase. We report the mean and median estimated coefficients across estimations and the p-values related to a t-test and signed rank test against the null hypothesis that the mean (median) coefficient is equal to zero.[13] We report the results for the full sample of firms and partitioned by exchange listing. Table 4 contains the results.

[11] As we only see ex post trading volume, inclusive of the repurchase activity, it is not possible to isolate order imbalances in this framework. We examine this issue in another context when we consider liquidity impacts of repurchasing.

[12] We measure cumulative abnormal returns as the buy-and-hold excess return of the stock relative to the S&P 500 over 3-day, 5-day, and 10-day windows in advance of and following days of successful repurchases. While we only present the 3-day estimations, the results are qualitatively the same for the 5-day and 10-day CAR analyses.

[13] We have also estimated a firm fixed-effect Tobit model. The results are qualitatively similar to those reported and are available from the authors upon request.

Table 4
Tobit estimation of daily repurchase intensity

	Full sample		NYSE		NASDAQ		NYSE vs NASDAQ	
	Mean	Median	Mean	Median	Mean	Median	*t*-test	Kruskal-Wallis
Intercept	−0.720	−0.329	−0.940	−0.341	−0.593	−0.323	0.179	0.034
	[0.0001]	[0.0001]	[0.0041]	[0.0001]	[0.0001]	[0.0001]	[0.8590]	[0.8528]
S&P 500 return	−5.762	−1.384	−16.312	−6.503	0.446	−0.219	−2.170	6.900
	[0.0466]	[0.0430]	[0.0095]	[0.0026]	[0.8592]	[0.8746]	[0.0111]	[0.0086]
Excess return	−2.373	−0.487	−5.684	−3.018	−0.453	−0.003	−2.919	8.565
	[0.1837]	[0.0166]	[0.2274]	[0.0106]	[0.5858]	[0.7019]	[0.0049]	[0.0034]
3-day CAR lag	−2.664	−0.505	−6.634	−1.810	−0.381	−0.060	−2.848	8.152
	[0.1083]	[0.0156]	[0.1244]	[0.0026]	[0.6587]	[0.8746]	[0.0060]	[0.0043]
3-day CAR lead	−0.930	0.147	−1.951	0.394	−0.343	0.029	0.778	0.617
	[0.4920]	[0.5066]	[0.5919]	[0.0931]	[0.5585]	[0.8639]	[0.4395]	[0.4323]
Nonrepurchase volume	0.260	0.119	−0.059	0.003	0.443	0.262	−5.118	26.267
	[0.0001]	[0.0001]	[0.1663]	[0.5548]	[0.0001]	[0.0001]	[0.0001]	[0.0001]
Percent of program completed	0.537	0.255	0.994	0.301	0.274	0.230	1.649	2.742
	[0.0086]	[0.0001]	[0.0532]	[0.0005]	[0.0384]	[0.0005]	[0.1042]	[0.0977]
Announcement	−1.644	−0.725	−1.814	−0.109	−1.544	−0.843	1.720	2.984
	[0.0001]	[0.0001]	[0.0385]	[0.0491]	[0.0001]	[0.0001]	[0.0904]	[0.0841]
Announcement within 5 days	−1.510	−0.537	−1.491	−0.151	−1.509	−0.740	1.949	3.825
	[0.0001]	[0.0001]	[0.0914]	[0.0573]	[0.0001]	[0.0001]	[0.0559]	[0.0505]
Observations	63		23		40			

Daily repurchase volume is estimated in a Tobit regression for each firm. The dependent variable is the daily number of shares repurchased. Independent variables include contemporaneous, lagged, and lead values of the return on the market, excess returns relative to the market, the percentage of the repurchase program completed, abnormal nonrepurchase volume, defined as each day's aggregate trading volume less reported repurchase volume, and indicator variables for days when the firm made public announcements. All volume variables are scaled by 100,000. We present the mean and median coefficient from the individual firm estimations and a parametric and nonparametric *p*-value against the null hypothesis that the mean (median) coefficient is equal to zero. We also present a parametric *t*-test and a nonparametric Kruskal-Wallis test of the equality of the estimated coefficients across the NYSE and the NASDAQ.

For the full sample of firms, we find that firms increase repurchasing during periods of high nonrepurchase trading volume. Importantly, all firms in our sample curtail repurchasing in the five-day window centered around firm-specific information releases. Thus they take care to avoid trading on inside information which is being publicly disseminated. Of interest is that as the repurchase program moves along through time, the size of daily repurchases increases. This may be driven in part by the SEC safe harbor rules for repurchasing shares.[14] The results regarding the return-related variables differ by exchange listing. For the 23 NYSE firms in our sample, we find that they repurchase more when the market is contemporaneously down, the excess return of the stock is lower, and when the cumulative abnormal return for the prior 3 days is more negative. Thus these firms appear to be price sensitive in the daily repurchase decision. For the 40 NASDAQ firms, we find no significant relationship between price movements and the number of shares repurchased. The NASDAQ firms are sensitive to the amount of nonrepurchase trading volume. Thus it appears that they attempt to hide among or consume exiting liquidity.[15] Neither subsample appears to repurchase consistently in advance of price increases.[16] Overall we conclude from the Tobit analysis that NYSE firms are price-sensitive repurchasers, at least at the choice of day level, and NASDAQ repurchasers are not. We next turn to the decision of when within a day to buy shares.

4.1 Within-day repurchase analysis

Barclay and Smith (1988) hypothesize that, by placing limit orders at which it is willing to buy shares, a firm could establish a lower bound on the bid price and thus help to support a falling stock price. They termed this use of limit orders to buy at the bid the "Competing market-maker hypothesis." Our regression results indicate that NYSE firms buy on down market days, consistent with both repurchasing as cheaply as possible and posting a stabilizing bid to help support a falling stock price. We examine the timing of trades and trade execution location relative to the

[14] SEC rule 10b-18 provides a safe harbor for repurchasing if repurchased shares remain below 25% of the average daily trading volume in the four calendar weeks prior to the week of the repurchase. Thus the allowable shares to repurchase is path dependent.

[15] Alternatively, due to the nature of the dealer market on NASDAQ, it may be that the repurchase transaction results in a matching dealer-to-dealer transaction. In this case there would be no intention of the firm to repurchase when volume is higher—nonrepurchase volume is higher due to the repurchase itself.

[16] Under a short-term timing hypothesis, it is the expectation of future returns that might determine repurchase intensity. We use realized returns in the estimations. Assuming the firms have unbiased but not perfectly accurate forecasts of their future returns, these coefficients are going to be biased toward zero due to measurement error. This may be one reason why the coefficients are insignificant. We thank the referee for pointing out this alternative hypothesis.

Table 5
Trade execution location and intraday returns

	NYSE repurchases				NASDAQ repurchases			
Panel A: Signed execution location								
	Below quote midpoint	Above quote midpoint	At quote midpoint	At bid	Below quote midpoint	Above quote midpoint	At quote midpoint	At bid
No. of trades	813	768	442	724	131	306	195	40
Share volume	8,470,700	7,366,700	3,992,200	7,709,800	1,801,600	5,500,700	3,871,200	903,700
Percent of volume	42.7%	37.2%	20.1%	38.9%	16.1%	49.2%	34.6%	8.1%
Panel B: Returns from quote midpoint to quote midpoint								
	Mean	Median	*t*-statistic	*p*-value	Mean	Median	*t*-statistic	*p*-value
Open to close	−0.66%	−0.23%	−12.01	[0.0001]	−0.04%	0.00%	−0.70	[0.4873]
Open to repurchase	−0.61%	−0.14%	−12.32	[0.0001]	−0.02%	0.00%	−0.39	[0.6946]
Repurchase to close	−0.05%	0.00%	−1.91	[0.0568]	−0.02%	0.00%	−0.71	[0.4788]

Panel A contains the trade execution location of all repurchase transactions partitioned by exchange listing. We provide the number of trades, the share volume, and the percent of the repurchase program that was executed below the midpoint of the bid-ask spread, above the midpoint of the spread, trades which were executed at the quote midpoint, and those that were executed at the prevailing market bid. Panel B examines intraday returns on repurchase days. We partition each trade day into two partitions; from the open to the repurchase trade, and from the repurchase trade, to the market close.

bid-ask spread to determine whether corporations are using limit or working orders at the bid in an attempt to establish a floor price.[17]

As can be seen in panel A of Table 5, 724 trades, representing 38.9% of NYSE repurchase volume, were bought at the prevailing bid. For NASDAQ firms, we only find 40 of 632, or 8.1%, of the repurchases at the prevailing bid. Thus trade execution location results for the NYSE firms are consistent with Barclay and Smith's (1988) competing market-maker hypothesis.

If firms are repurchasing with a price support motivation (and they are successful), we should see prices falling within-day in advance of a repurchase trade and stabilizing or rising after the repurchase. To investigate this possibility, we examine intraday returns surrounding repurchase trading. We partition each trade day return into two parts — return from the open to the repurchase and return from the repurchase to the close — to determine if firms are buying in advance of the price drop or following the price drop. We calculate intraday returns using the midpoint of the current bid-ask spread to eliminate the effect of bid-ask bounce in our analysis.

Results are contained in panel B of Table 5. Consistent with our regression results, we find that NYSE firms are buying on "down-trending" days. The price of NYSE stocks falls by .66% (p-value = .0001)

[17] We assign quotes to trades using a five-second lag, as suggested by Lee and Ready (1991).

from the open to the close on repurchase days. On the NYSE, prices fall by −.61% (p-value = .0001) from the open to the repurchase and only drop by an additional .05% (p-value = .0568) from the repurchase to the close. Thus, on repurchase days, more than 90% of the price movement occurs prior to repurchase trades. We find a falling price immediately prior to repurchase, purchasing at a low price (the bid price), and a relatively stable price following the repurchase. Thus NYSE repurchases seem to absorb downward price pressure and act as a stabilizing mechanism. In contrast, on the NASDAQ, the stock price is flat on repurchase days. Our NASDAQ firms appear to exhibit no impact on prices when they repurchase.

5. Other Evidence of Liquidity Impact

While we have presented some evidence of repurchase execution behavior that could result in a more liquid market for a repurchasing company's stock, the execution behavior should also affect traditional measures of liquidity like spread and price impact. By way of review, the existing literature has argued that there are two ways a firm's repurchase program can affect the liquidity of a stock. Consistent with our evidence that repurchase trading can supplement liquidity on the bid side, Barclay and Smith (1988) suggest that regular repurchases can provide competition for market makers and potentially make a firm's shares more liquid. By posting limit orders to buy, the firm can establish a lower bound price for a stock and in doing so effect a narrowing of the bid-ask spread during execution. In this case, increased liquidity is related to a narrowing of the bid-ask spread. Alternatively, Barclay and Smith (1988) also argue that, beginning with the announcement of an open market repurchase program, an asymmetric information effect of possibly trading with an informed trader (the corporation) may widen spreads. It is possible that this program-long widening may dominate any execution-related market-making effect and result in a net widening of the bid-ask spread during the program.[18] Even if there is a wider spread during the repurchase period overall, our dataset allows us to examine execution-related temporary narrowing within this wider spread to see if firms are competing with other buyers to provide liquidity to sellers.

A second means of affecting market liquidity is to absorb sell-side pressure by standing ready to buy shares at the bid without allowing the

[18] Others investigating the potential spread widening in the United States have not always concurred that there is a repurchase-related widening in the spread [see, e.g., Singh, Zaman, and Krishnamurthi (1994) and Miller and McConnell (1994)]. Brockman and Chung (2001) investigate the liquidity impact of repurchasing in Hong Kong. They document spread widening on repurchase days, consistent with an asymmetric information effect. Importantly, repurchase trading is disclosed by the start of trading on the following business day in Hong Kong. Thus when a repurchase program is initiated (as opposed to announced), market participants are informed of the corporate presence.

price to fall. To examine this aspect of liquidity, we consider the change in a firm's stock price in the presence of sell-side pressure.[19] The higher the change in price resulting from a trade, the lower the liquidity. Using a methodology developed by Breen, Hodrick, and Korajczyk (1999), we examine whether the price impact of trades differs on repurchase days from that on nonrepurchase days. That is, we examine if repurchasing firms, by absorbing sell-side order imbalances, limit the negative price impact generally associated with large order imbalances.

5.1 Bid-ask spread effects

Isolating repurchase impact on spreads is challenging because we do not know (i) how and when managers communicate or signal their intent or willingness to buy to a broker, and (ii) how brokers use, or communicate to others, corporate intent. Communication may not constitute an explicit order. For instance, the repurchasing firm may call a broker and seek current quotes while indicating that it may be in the market for 50,000 shares. While not an order, the communication can influence quotes.[20]

To address liquidity provision within the repurchase period, we make paired comparisons of spreads on repurchase days to spreads on adjacent nonrepurchase days and to spreads during a time period uncontaminated by repurchase trading.[21] We use a transactions-based spread calculation methodology to reflect transaction-relevant spreads. The statistics are computed using the spreads attached to actual transactions. This procedure ignores regional autoquotes, and other types of noncompetitive and stale quotes. We define the ask (bid) prevailing at the time of the nth transaction on firm i's stock on day t as a^i_{nt} (b^i_{nt}).[22] The spread is defined as $s^i_{nt} = a^i_{nt} - b^i_{nt}$ with a daily average spread for firm i on day t of $\overline{s}^i_t$. We focus on comparisons of $\overline{s}^i_t$ for repurchase days and three benchmarks: the

[19] Since firms can only buy shares, they can only confer this type of liquidity benefit during periods of sell-side order imbalance.

[20] It is important to consider the impact of alternative market structures in this type of analysis. The limit order book on the NYSE provides a direct venue for firms to influence the spread proactively. The absence of a publicly displayed limit order book on the NASDAQ (during the time of this study) made it difficult for corporations to have the same direct influence on quoted spreads. Market makers were under no obligation to either publicly display limit orders or update their posted quotes to reflect limit orders that bettered their quotes. However, repurchase trading does affect market depth. On average, repurchase trading provides one third of a repurchase day's trading volume on NASDAQ. This assurance of greater trading depth (or verbal indications of interest) may prompt market makers to change their quotes, an indirect effect rather than the direct effect of displaying the limit order.

[21] We choose the four calendar weeks prior to the week of the announcement of the repurchase program as an uncontaminated trading period. We calculated an average spread for each the 50 firms with identifiable announcements where there was no evidence of an ongoing repurchase program and label this the "prerepurchase" benchmark.

[22] The prevailing bid and ask refer to the best bid and offer (BBO), which we calculate for NYSE stocks using quotes from all regional exchanges. TAQ reports only the BBO for NASDAQ stocks, not the individual quotes from which the BBO is calculated.

Table 6
Bid-ask spread liquidity effects

	Repurchase day spread	Prerepurchase period relative spread difference	Lag day relative spread difference	Lead day relative spread difference
Full sample	.3706	−0.0796	−0.0085	−0.0101
		(0.0338)	(0.0082)	(0.0042)
		[0.0013]	[0.0189]	[0.0024]
NASDAQ	.4370	−0.1106	−0.0112	−0.0127
		(0.0326)	(0.0398)	(0.0381)
		[0.0001]	[0.0912]	[0.0332]
NYSE	.1998	0.0004	−0.0053	−0.0071
		(0.9638)	(0.0586)	(0.0077)
		[0.9515]	[0.0591]	[0.0345]

We compute statistics on daily average spread data for all repurchase days and on the spread differences relative to select nonrepurchase days. Differences are defined as the repurchase spread minus the appropriate benchmark spread. The nonrepurchase days we choose are a prerepurchase period (the average of four weeks prior to the week of the first repurchase), the lag day defined as the day preceding a repurchase if no repurchase occurred on the lag day, and the lead day defined as the day following a repurchase if no repurchase occurred on the lead day. For example, if a firm repurchases on three consecutive days, the first day will have a lag benchmark and the third day will have a lead benchmark, however, the middle trade day will have neither a lead or lag comparison. *p*-values from Student's *t* and Wilcoxon signed rank statistics are shown in parentheses and brackets, respectively, against the null hypothesis that the mean and median spread difference between the repurchase day and nonrepurchase day is equal to zero.

prepurchase period, lead days, and lag days.[23] Abnormal spreads are defined as the repurchase day spread less the spread on the benchmark day. In the statistics we present, the spread measures are constructed by first calculating an average spread for each firm and then averaging the averages across firms (rather than simply averaging abnormal spreads across all firm trade days, which gives undue influence to firms with many days of repurchases).

Table 6 contains daily abnormal spread measures. The average daily spread for the firms in our sample is 37 cents. Relative to the prerepurchase period, this represents a narrowing of nearly eight cents. For the NASDAQ firms in our sample, the average daily spread narrows by 11.1 cents relative to the prerepurchase period. To the contrary, on the NYSE, the spread remains unchanged relative to the prerepurchase period.

The abnormal spreads relative to lag and lead benchmarks are significantly negative and average about one cent.[24] The results hold for both the NYSE and the NASDAQ subsamples. Overall our results support the notion that open market repurchase executions can, through the

[23] A lead (lag) benchmark refers to the day before (after) a repurchase day when the corporation did not repurchase. Thus if a firm repurchases on three consecutive days, the first day will have a lead benchmark and the third day will have a lag benchmark. The second day will have neither a lead nor lag benchmark.

[24] See Ahn, Cao, and Choe (1996) for a microstructure discussion of the economic significance of changes in quoted bid-ask spreads. They demonstrate the economic and statistical significance of small dollar spread changes, for example, one cent.

narrowing of spreads, provide a liquidity benefit to the market. In addition, we find no evidence to support an asymmetric information repurchase-related spread widening as found by Brockman and Chung (2001).

Consistent with our goal of characterizing repurchase execution strategies, our emphasis is primarily the documentation of statistically significant patterns in repurchase behavior and market impact. Nonetheless, we also believe that many of our results provide evidence of the economically significant impact repurchase programs can have on NYSE and NASDAQ trading. For a change in spread of 11 cents relative to the prerepurchase period for NASDAQ firms, there is little doubt that the economic stakes are significant. We would argue that even a one-cent change in spread for the repurchase day represents a potentially significant economic impact for the large volume of other traders active on a repurchase day.

5.2 Price impact liquidity effects

The second measure of liquidity we consider is the change in a firm's stock price associated with its observed trading volume. The higher the change in price resulting from a trade, the lower the liquidity. Adopting the Breen, Hodrick, and Korajczyk (1999; hereafter BHK) "net turnover" approach, we examine the price impact of trades on repurchase days relative to nonrepurchase days. We partition each trading day into thirteen 30-minute trading windows and calculate a return using the midpoint of the quoted bid-ask spread during each window. Net turnover (NTO) is defined as buyer-initiated volume less seller-initiated volume as a fraction of shares outstanding.[25]

We estimate three regressions for each firm, using the half-hourly observations of return and NTO to estimate the relationship between 30-minute NTOs and 30-minute returns for repurchase and nonrepurchase days. We include an indicator variable (R) set to one if the firm made a repurchase on a day and interact the indicator with the NTO variable. We report results across all market conditions and also partition the results based on whether NTO is positive (buy pressure) or negative (sell pressure) to isolate the impact of repurchasing behavior under each scenario. We report the mean coefficient across the firm-specific estimations in panel A of Table 7. The estimation equation takes the form

$$\text{Return} = \alpha_1 + \beta_1 NTO + \beta_2 (R * NTO) + \epsilon.$$

As BHK have documented, the typical relationship between return and the signed variable NTO is positive. That is, a larger positive NTO is correlated with a larger positive return. A larger negative NTO is

[25] Following BHK (1999), we classify every trade as buyer initiated or seller initiated based on whether the trade price is greater than or less than the quote midpoint.

Table 7
Price impact liquidity effects

Panel A

	Intercept	NTO (β_1)	$R *$ NTO (β_2)
NYSE estimations			
Negative NTO	−0.0928	0.4115	−0.0941
	[0.0001]	[0.0001]	[0.0616]
Positive NTO	0.0511	0.5802	−0.1794
	[0.0001]	[0.0001]	[0.0312]
All NTO	−0.0084	0.6274	−0.1487
	[0.5227]	[0.0001]	[0.0187]
NASDAQ estimations			
Negative NTO	−0.0053	0.0422	−0.0255
	[0.0600]	[0.0024]	[0.0576]
Positive NTO	0.0001	0.0845	−0.1045
	[0.3606]	[0.0001]	[0.0475]
All NTO	0.0038	0.0566	−0.0520
	[0.3151]	[0.0001]	[0.0004]

Panel B

	NYSE estimations		NASDAQ estimations	
The constant and coefficients on firm indicators are not reported.				
NTO (β_1)	0.211	0.123	0.035	0.005
	[0.0001]	[0.0001]	[0.0001]	[0.0748]
Negative (α_2)	−0.197		−0.024	
	[0.0001]		[0.0001]	
NTO $*$ Neg (β_2)	−0.100		−0.018	
	[0.0001]		[0.0055]	
$R *$ Neg (α_3)	0.022		0.001	
	[0.0090]		[0.9344]	
$R *$ Neg $*$ NTO (β_3)	0.007		−0.017	
	[0.6966]		[0.0077]	
Positive (α_2)		0.168		0.018
		[0.0001]		[0.0007]
NTO $*$ Pos (β_2)		0.183		0.065
		[0.0001]		[0.0001]
$R *$ Pos (α_3)		0.0193		0.019
		[0.0249]		[0.0441]
$R *$ Pos $*$ NTO (β_3)		−0.1660		−0.063
		[0.0001]		[0.0001]
Adjusted R^2	0.0633	0.0623	0.0085	0.0120

Panel A: Each day is partitioned into 13 half-hour trading windows. The dependent variable in the estimation is the return in each time window measured as the change in the midpoint of the bid-ask spread from the beginning of the period to the end of the period. We estimate three regressions for each firm and report the mean coefficient across estimations. The first isolates repurchase impact under periods of sell pressure. The second regression isolates repurchase impact under periods of buy pressure. The third does not partition by buy or sell pressure. The independent variables are the net turnover (NTO) measured as the buy volume during the period less the sell volume during the period, scaled by shares outstanding, and an indicator variable set to one ($R = 1$) for days of successful repurchase. *p*-values are reported in [brackets].

Panel B: We estimate two fixed-effects regressions. The first isolates repurchase impact under periods of sell pressure. The second regression isolates repurchase impact under periods of buy pressure. The independent variables are the net turnover (NTO) measured as the buy volume during the period less the sell volume during the period, scaled by shares outstanding, and three indicator variables. We code (Neg = 1) for periods of negative NTO and zero otherwise. We code (Pos = 1) for periods of positive NTO and zero otherwise. We also include an indicator set to one ($R = 1$) for days of successful repurchase. *p*-values are reported in [brackets].

correlated with a larger negative return. Our firms exhibit this same general relationship. However, our interest is the influence of repurchasing programs on this relationship. In our estimations, the coefficient β_2 should capture any repurchase-related impacts on the NTO-return relationship.

There are two ways in which a repurchasing firm's buying behavior can affect the usual relationship between NTO and price changes. The first and easiest to understand is when a repurchasing firm leans against selling pressure to absorb some of it by buying from those wishing to sell (provides price support). Conditional on overall selling pressure ($\text{NTO} < 0$), the repurchaser's demand for shares can increase the price from what it would otherwise have to be to satisfy the selling pressure (relative to when the repurchaser is not in the market). If repurchasers are absorbing selling pressure, we expect a negative NTO to be greeted by a higher than "usual" price. This implies a smaller than usual price change (down). This attenuation of price decrease (or relative price increase) implies a regression coefficient on $R * NTO$ that is negative (so that the product of the coefficient and $R * NTO$ is positive). The results in panel A of Table 7 indicate that for the subset of data where there is selling pressure ($\text{NTO} < 0$), the coefficient on $R * NTO$ has the predicted negative sign and is statistically significant for both NYSE and NASDAQ firms.

The second way a repurchasing firm's buyer behavior can influence the relationship between NTO and price change is when the repurchasing firm is a component of buying pressure during periods of overall buying pressure ($\text{NTO} > 0$). Here we have a similar attenuating effect when the repurchaser is more patient than other contributors to buy-side pressure. For a given level of $\text{NTO} > 0$, if the repurchase demand on the ask side is more patient than other purchasers, the price increase necessary to satisfy demand-side pressure should be lower. When patient repurchasing demand is present, we expect the positive NTO to be greeted by a lower than usual price (and correspondingly a lower than usual price increase). This attenuation of price increase has a regression reflection involving a coefficient on $R * NTO$ (now a positive variable) that is negative (so that the product is negative). Panel A of Table 7 indicates that for the buying pressure subset ($\text{NTO} > 0$), the coefficient on $R * NTO$ has the predicted negative sign and is statistically significant for both NYSE and NASDAQ firms.

In panel B of Table 7, we introduce a firm fixed-effects regression, pooling all firms and days together. This allows us to consider all cases of NTO (positive, negative, and zero) simultaneously. We use multiple dummy variables to condition on market pressure [negative ($Neg = 1$) or positive ($Pos = 1$) NTO] and the presence of a repurchaser ($R = 1$). With the inclusion of market-neutral data ($\text{NTO} = 0$), the dummy variables allow us to calibrate changes from neutrality. The coefficients $\sum_{i=1}^{T} \alpha_i$

capture firm-specific effects. The estimations take the form

$$\text{Return} = \alpha_1 + \sum_{i=2}^{T} \alpha_i + \beta_1 NTO + \alpha_2 Neg + \beta_2 (Neg \cdot NTO) + \alpha_3 (R \cdot Neg) + \beta_3 (R \cdot Neg \cdot NTO) + \epsilon$$

$$\text{Return} = \alpha_1 + \sum_{i=2}^{T} \alpha_i + \beta_1 NTO + \alpha_2 Pos + \beta_2 (Pos \cdot NTO) + \alpha_3 (R \cdot Pos) + \beta_3 (R \cdot Pos \cdot NTO) + \epsilon.$$

The results are essentially similar to those in the subset regressions of panel A. The estimated coefficient β_3 captures the impact of repurchasing on the order imbalance-return relationship. In the firm fixed-effects regression, the coefficients (β_3) on $R * NTO$ (now interacted with overall market indicators) are negative as before. Thus our modified BHK approach provides additional evidence that corporate repurchase trades contribute to, rather than diminish, liquidity, at least relative to other potential purchasers.

6. Market Timing Ability

We have demonstrated that firms do have an impact on market liquidity through their repurchasing presence. We have also demonstrated that they can provide price support and stem the tide of a falling price. The final issue we consider is whether at an aggregate level, they are able to time the market from a cost-minimization perspective. That is, aggregating across the entire repurchase program, do they beat naive accumulation strategies? Since motives and objectives regarding the announcement and execution of a repurchase program may vary substantially across firms, we base our analysis on the assumption that, ceteris paribus, repurchasing firms prefer low acquisition costs on the repurchase portfolio.

We begin by evaluating the firms' timing decisions on the chosen trading days. That is, was their purchase price above or below the price of other trades on the same day? We compare the share-weighted average repurchase price for each day with the share-weighted average price of all nonrepurchase volume for the day.[26] Table 8 provides details. On the NYSE, firms pay an average of two cents less per share than noncorporate trades. The difference is significant at conventional levels. On the NASDAQ, corporations pay nearly 10 cents more per share than noncorporate

[26] This execution skill measure is similar to that proposed by Manaster and Mann (1996) for assessing execution skill for futures traders, although their time interval is much shorter and they construct benchmarks for buys and sells separately. Benchmarking repurchase execution only against signed buys could be misleading because successful limit order repurchases would usually be signed as sells.

Table 8
Repurchase price comparison

	NYSE price relatives		NASDAQ price relatives	
	Dollars	Percent	Dollars	Percent
Mean	−$0.0202	−0.056%	$0.0998	0.865%
Median	−$0.0063	−0.018%	$0.0948	0.669%
t-statistic	−3.58	−3.83	13.47	13.46
p-value	[0.0004]	[0.0001]	[0.0001]	[0.0001]

The actual daily repurchase price paid relative to the noncorporate trade price on the day of the repurchase presented in dollars and as a percentage of weighted average daily price for the 2190 repurchase days in the sample. Mean and median values are provided. *t*-statistics and *p*-values from tests against the null hypothesis of no difference in price paid (dollar and percent) by the corporation relative to the market are provided.

trades. The difference is statistically significant and economically meaningful, representing nearly 1% of the purchase price. In addition, as reported in Table 5, more than 40% of NYSE repurchases are executed below the quote midpoint, whereas only 16% are similarly executed for the NASDAQ. Thus, taking the choice of trade day as given, NYSE firms appear to have good execution skills, whereas NASDAQ firms pay significantly higher relative prices.

We next evaluate each firm's skill in selecting days to trade over the course of a repurchase program. The measurement of timing in a repurchase framework is not the same as that of a typical portfolio manager. Traditional measures, such as those discussed in Grinblatt and Titman (1993), exploit the ability of traders to buy *and* sell securities. Since U.S. corporations only have discretion over when they buy shares, they face an optimal accumulation problem rather than a traditional market timing problem. Thus we evaluate actual accumulation strategies against other accumulation strategies that achieve the same ultimate share holdings (and have the same terminal wealth).

The benchmarks we consider relate to the cost of acquiring the same number of shares as actually repurchased through different repurchase patterns. We begin with the actual dollar cost of a program:[27]

$$AC_i = \sum_{t \in RD_i} \overline{P}_{it} V_{it}^R, \tag{1}$$

where AC_i is the dollar cost for firm i, RD_i is the set of days firm i was successful in repurchasing, $\overline{P}_{it}$ is the average price paid by firm i on day t, and V_{it}^R is the volume (number of shares) repurchased by firm i on day t. The 64 repurchase programs cost an average of $45.7 million, with a range of $147,875 to $500,000,000. We compare each program's performance against several, although certainly not all, reasonable benchmarks.

[27] The portfolio costs we evaluate do not include commissions.

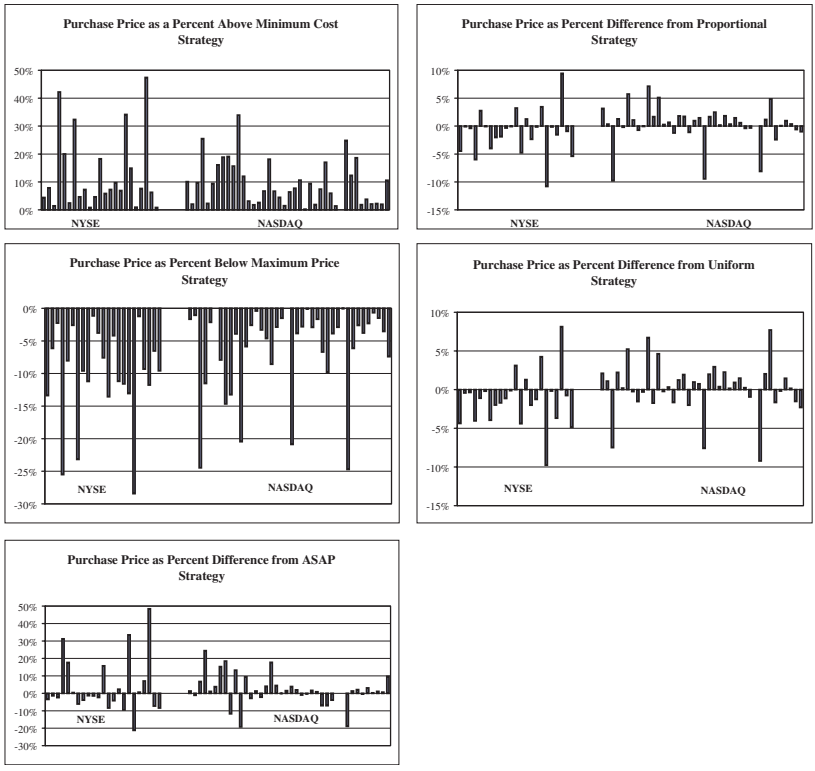

Figure 4
The actual repurchase cost for each of the 64 programs in our study are presented as a percentage of five different cost-based benchmarks; uniform, proportional, as soon as possible, minimum, and maximum cost.

The minimum (maximum) cost strategy assumes that shares were repurchased at the lowest (highest) feasible aggregate price during the repurchase period.[28] Figure 4 plots firm-by-firm results relative to the benchmarks. Table 9 contains details. The average NYSE program costs \$116.3 million, with a median of \$62.8 million. The NYSE firms pay on average \$12.3 million above the minimum cost, but about \$15 million less than the maximum cost. In percent terms, the median difference from the cost benchmarks is +6.5% and −10.8%. The statistical tests for dollar and percent differences (where each firm provides one observation) indicate that NYSE repurchasing firms do significantly better than the maximum cost benchmark and worse than the minimum cost. The NASDAQ programs in our sample, averaging only \$6.1 million, are significantly smaller than those for the NYSE. Our NASDAQ firms pay on average \$570,652

[28] These measures represent theoretical upper and lower bound costs to acquire the reported repurchased shares during each repurchase program. We do not claim that firms could execute our benchmark strategies. For example, SEC rule 10b-18 provisions restrict firms conforming to rule 10b-18 from repurchasing during the last half hour of the trading session.

Table 9
Repurchase cost comparisons

	Full sample cost relatives		NYSE cost relatives		NASDAQ cost relatives		NASDAQ vs NYSE tests of equality	
	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent
				Minimum cost				
Mean	4,791,588	9.0%	12,315,863	10.2%	570,652	8.4%	4.82	0.28
	[0.0035]	[0.0001]	[0.0052]	[0.0001]	[0.0005]	[0.0001]	[0.0001]	[0.7796]
Median	564,631	6.9%	4,219,111	6.5%	151,753	7.0%	23.37	0.08
	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.7742]
				Maximum cost				
Mean	−5,788,561	−9.1%	−15,259,686	−12.5%	−475,490	−7.1%	−5.39	−2.69
	[0.0053]	[0.0001]	[0.0062]	[0.0001]	[0.0058]	[0.0001]	[0.0001]	[0.0092]
Median	−397,922	−5.5%	−6,016,445	−10.8%	−134,822	−3.8%	29.09	7.25
	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0071]
				Uniform cost				
Mean	−508,602	−0.4%	−1,414,910	−1.5%	−185	0.2%	−3.61	−2.66
	[0.1374]	[0.4087]	[0.1383]	[0.0902]	[0.9965]	[0.6470]	[0.0006]	[0.0099]
Median	−7,146	−0.2%	−580,716	−1.2%	2,300	0.3%	13.08	7.10
	[0.1909]	[0.5602]	[0.0385]	[0.0188]	[0.1691]	[0.2471]	[0.0003]	[0.0077]
% > 0	45.3%		17.4%		61.0%			
				Proportional cost				
Mean	−529,147	−0.3%	−1,474,062	−1.3%	927	0.3%	−3.12	−2.46
	[0.1979]	[0.5614]	[0.2007]	[0.1658]	[0.9818]	[0.5635]	[0.0027]	[0.0138]
Median	344	0.0%	−490,740	−0.5%	8,325	0.6%	9.78	6.10
	[0.4851]	[0.6797]	[0.0948]	[0.0573]	[0.0627]	[0.0296]	[0.0018]	[0.0135]
% > 0	50.0%		21.7%		65.9%			
				ASAP cost				
Mean	49,045	1.1%	−432,265	0.8%	319,048	1.3%	−1.69	−1.54
	[0.9750]	[0.4361]	[0.9223]	[0.7897]	[0.0284]	[0.3942]	[0.0905]	[0.1288]
Median	7,360	0.6%	−505,677	−1.5%	13,565	1.3%	2.89	2.39
	[0.4500]	[0.3704]	[0.4065]	[0.6371]	[0.0130]	[0.0570]	[0.0891]	[0.1221]
% > 0	54.7%		39.1%		63.4%			
				Closing price cost				
Mean	17,838	0.3%	32,107	0.05%	9,834	0.4%	−1.18	−4.45
	[0.3289]	[0.0495]	[0.5227]	[0.4039]	[0.1713]	[0.0633]	[0.2399]	[0.0001]
Median	5,656	1.3%	5,187	0.04%	6,125	0.4%	1.40	19.86
	[0.0032]	[0.0005]	[0.5155]	[0.3264]	[0.0015]	[0.0015]	[0.2371]	[0.0001]
% > 0	67.2%		56.5%		73.2%			

Actual repurchase cost is compared to several repurchase strategies over the repurchase horizon. Mean and median relative costs are provided. *p*-values from paired *t*-tests against the null hypothesis of no difference in price paid (dollar and percent) by the corporation relative to the six naive accumulation strategies are provided. We present values for the entire sample and partitioned by exchange listing. We also present parametric *t*-tests and nonparametric Kruskal-Wallis tests against the null hypothesis of equality across the NYSE and NASDAQ results.

more than minimum cost, but \$475,490 less than maximum cost. The overall worst execution firm pays nearly \$85 million more than the minimum cost (in a total program value of \$500 million); the best execution is equal to the minimum cost.[29]

A more realistic benchmark might be the cost of buying the same number of shares by accumulating them uniformly over the entire

[29] One firm repurchased on only one day and traded at the lowest price for the day.

reported repurchase period.[30] For each day, starting with the first reported repurchase through the last reported repurchase, our "uniform" strategy buys a fixed number of shares every day at the closing price. The uniform repurchase cost (UC) is defined as

$$UC_i = \frac{\sum_{t=1}^{T_i} P_{it}^c}{T_i} V_i^R, \tag{2}$$

where T_i is the number of trading days in the repurchase horizon for firm i, $V_i^R = \sum_t V_{it}^R$ is the number of shares in the terminal repurchase portfolio, and P_{it}^c is the closing price on day t for firm i.

A second naive benchmark buys in proportion to each day's trading volume. The proportional repurchase cost (PC) for firm i is defined as

$$PC_i = \frac{\sum_{t=1}^{T_i} V_{it} P_{it}^c}{V_i} V_i^R, \tag{3}$$

where $V_i = \sum_t V_{it}$ is the total volume over the repurchase horizon and V_{it} is the total shares traded on day t in stock i. The third naive strategy we consider is repurchasing "as soon as possible" (ASAP) subject to trading volume for the day. We assume the corporation repurchases 100% of the trading volume beginning the first day of an actual repurchase and continues taking 100% of each consecutive day's volume until all desired shares are repurchased. The final benchmark we consider examines the cost of buying the program at the closing price for each actual repurchase day. Thus this measure examines, from a program-wide perspective, the within-day timing of trades. The closing repurchase cost (CC) for firm i is defined as:

$$CC_i = \sum_{t \in RD_i} P_{it}^c V_{it}^R, \tag{4}$$

where CC_i is the dollar closing cost for firm i, RD_i is the set of days firm i was successful in repurchasing, P_{it}^c is the closing price for firm i on day t, and V_{it}^R is the volume (number of shares) repurchased by firm i on day t.

Table 9 provides details for these additional cost-based benchmarks. Apparent differences between NYSE and NASDAQ timing skill emerge. We find that the 41 NASDAQ programs pay more than if they had repurchased as soon as possible. That is, their decision to wait to repurchase was on average \$319,048 more expensive than if they had been able to repurchase all shares as quickly as possible. The average percent difference from the ASAP benchmark is 1.3%, with 63% of NASDAQ firms' having higher than ASAP benchmark costs. NASDAQ costs were

[30] We begin the accumulation on the day of the first actual repurchase, which ensures that some funds were available to consummate repurchases. Prior to this date, an announcement of a program does not assure that the capital has been made available to those responsible for repurchase execution.

not significantly different from the uniform or proportional benchmarks. Relative to the closing cost benchmark, the NASDAQ firms paid significantly more in both dollars and percentage terms. Overall, 30 of the 41 NASDAQ firms underperformed this simplistic benchmark.

The 23 NYSE firms, in contrast, appear to exhibit some timing skill. Their acquisition costs are lower than the uniform and proportional benchmarks, saving an average of $1.4 million per program. Only 17.4% of the NYSE firms paid more than the uniform benchmark cost and 21.7% paid more than the proportional benchmark cost. While NYSE firms' acquisition costs were not significantly less than the ASAP costs, 14 of 23 firms (60.8%) did pay less than purchasing as soon as possible.

The reported means and medians mask the fact that some NASDAQ firms have good cost-based performance and a few NYSE firms have poor cost-based performance. Examination of the proportional benchmark reveals that 5 of 23 NYSE programs (21.7%) had timing decisions worse than a proportional approach, and 12 of 41 NASDAQ firms (34.1%) actually beat a proportional strategy. The nonuniformity of results within exchange-listing is consistent with the diversity of styles we highlighted in Section 2. Perhaps most provocative is the suggestion that NYSE firms' accumulation strategies appear on average to outperform those of NASDAQ firms. We find that the NYSE firms outperformed the NASDAQ firms for four of six accumulation strategies. We only find no difference in performance relative to the minimum cost and the ASAP accumulation strategies.[31]

7. Conclusion

It is difficult to characterize a "typical" open market repurchase program. Firms exhibit a diversity of styles in timing repurchase trades. Notwithstanding the inherent variety in repurchase programs, we find that the daily decision to repurchase is sensitive to local price and volume conditions, and, for NYSE firms, may involve timing or execution expertise relative to naive benchmarks. Regarding evidence whether corporations adapt their repurchases to inside information, our results indicate that, on average, firms appear to take some care to avoid the appearance of opportunistic trading by refraining from repurchasing around announcement dates. In addition, we find the widespread use of limit orders for executing repurchases. The use of limit orders is consistent with both the desire to provide liquidity by absorbing sell-side pressure and the desire to support a falling stock price.

[31] Risk- and time-adjusted excess wealth creation measures provide no additional insight. We have calculated expected excess wealth based on (1) the ex ante risk-free rate and (2) a capital asset pricing model (CAPM)-based rate of return, and find no evidence of significant abnormal wealth creation due to repurchase execution. However, consistent with the cost-based analysis, NYSE firms do beat the naive uniform, proportional, and closing cost repurchase strategies even after controlling for risk.

Counter to the results of Brockman and Chung (2001) for Hong Kong equities traded in a closely regulated environment, we find that U.S. repurchase trading contributes to market liquidity. Our evidence indicates that repurchase activity coincides with narrower bid-ask spreads relative to three different benchmark periods: (i) prior to the repurchase announcement; (ii) on nonrepurchase days immediately before days with repurchase transactions; and (iii) on nonrepurchase days immediately after days with repurchase transactions. We argue that the documented spread narrowing is consistent with the notion that, at the time of a repurchase transaction, the corporation on average competes with market makers to provide liquidity on the bid side of the market. Overall we find convincing evidence that repurchase trading confers at least local liquidity advantages to those trading the corporation's equity.

Open market repurchase programs are an increasingly important aspect of a company's payout policy and its treasury function. Due to the veil behind which repurchase trading takes place, we know very little about how open market repurchase programs are executed. Although current U.S. disclosure policy inhibits a more universal investigation of the costs and benefits of U.S. repurchase trading, our study of voluntarily disclosed data suggests that open market repurchases provide a potentially important liquidity benefit, the scope and magnitude of which appear to interact with the underlying market structure.

Appendix A

Open Market Stock Repurchase Survey and Data Sheet

Firm Name:

Type of Security Repurchased (e.g. Leach Corp. Class A Common):

Targeted Program
Starting Date:
Dollar Amount:
Number of Shares:

Program Status
_____ Completed
_____ Ongoing
_____ Suspended or withdrawn
_____ Uncertain

If a target number or value of shares was not achieved, why was the program suspended or withdrawn?

Position title or type of agent designated to coordinate repurchase trading:

Is there someone we can contact if we have questions?

Would you like to receive a copy of the completed study report (completed form is required)?

General comments on trade execution and costs:

Page 2

Date	Exchange (If Known)	Number of Shares (Actual not Round Lots)	Price Paid per Share (1/8ths or Decimal)	Price Aggregation* (E = Exact, A = Average)	Comments

Appendix B

To examine repurchase execution skill, transaction-level repurchase data are necessary. Most firms in our sample provided aggregate volume and average price for a given trading day. Some firms provided daily volume repurchased at a given trading price. For low trading volume stocks, visual identification of repurchase transactions in the TAQ data is straightforward. Consider the following example. On one day, a firm reported repurchasing 31,000 shares at a price of \$7.125 per share. The following is the TAQ listing of transactions in that stock for the given day:[32]

Print	Time	Bid	Ask	Price	Shares
1	34268	\$6.750	\$7.500	\$7.500	100
2	35841	6.750	7.500	7.500	500
3	42677	6.750	7.500	7.000	31000
4	42700	6.750	7.500	7.125	31000
5	45273	6.750	7.500	6.750	500
6	51974	6.750	7.500	7.500	100
7	54702	6.750	7.500	7.500	200
8	57105	6.750	7.500	7.125	1000
9	58163	6.750	7.500	7.000	300

Transaction 4 is the only feasible execution of 31,000 shares at a price of \$7.125. No grouping of other trades provides the required price-volume combination. In other cases the reported volume is not feasibly executed as a single print. For example, another corporation reported repurchasing 26,500 shares at an aggregate cost (exclusive of commissions) of \$542,437.50. There were five transactions in the stock for that day:

Print	Time	Bid	Ask	Price	Shares
1	41293	\$20.250	\$20.750	\$20.250	20000
2	41349	20.250	20.750	20.500	20000
3	41771	20.250	20.750	20.250	1200
4	42879	20.250	20.750	20.250	4000
5	42907	20.250	20.750	20.375	6500

The only feasible combination of trades that achieves the reported cost-volume repurchase is 2 and 5. For both of these low-volume examples, perfect identification of reported repurchases is not difficult.

For high-volume stocks, visual identification is not feasible and computer-based searching is required. We use combinatorial methods to identify combinations of a day's prints that together equal the reported repurchase price and volume. Due to computing constraints, we stop searching on high-volume days at quadruplets.[33] As we are unable to search through all feasible combinations of prints, we consider simplicity. If a repurchase can be explained by a single print, we "identify" the print as a repurchase. We discontinue our search for that volume and price at higher complexity levels, for example, in two prints (pairs). If a reported repurchase cannot be explained by a single print, but is consistent with a unique pair, we treat the pair as repurchases and discontinue our search. If a paired execution is not feasible, we

[32] Time is presented in seconds from midnight. The markets open at 33,480 seconds, or 9:30 A.M.

[33] For one NYSE firm, we could only search through combinations of three prints. For this firm, on one day there were 2951 transactions in the stock; a search for all combinations of four prints requires examining 3,153,423,033,475 combinations.

consider triplets, and so on. Using this heuristic approach, we can "identify" 1981 repurchases: 1114 singletons, 228 pairs, 85 triplets, and 39 quadruplets across 63 tickers.

As might be anticipated, the combinatorial search frequently generates more than one matching combination at a given level of complexity (e.g., 15 pairs). In these instances we search for common trades occuring in all combinations at the given level of complexity. For example, if we are searching for 10,100-shares at $30.00, and find 15 feasible pairs, each containing the same 10,000-share at $30.00 print, but matched with 15 different 100-share at $30.00 prints, we classify the 10,000-share print as an identified repurchase in a partially identified pair. The 100-share portion remains "unidentified." We can identify an additional 674 prints using this within-complexity procedure. Overall, of the 3585 reported repurchases across 2190 firm-days, we can identify 2655 prints on 1431 firm-days representing more than 31 million shares.

We recognize that our heuristic is not perfect and offer three defenses:

1. The measures of execution timing and skill that consider aggregate daily reported repurchase price and volume are not subject to error from transaction misidentification.
2. Misidentification will tend to diminish differences and bias against significance in our transactions-level tests.
3. We ran exhaustive combinations on the subset of reported repurchases where (i) there were not more than 30 prints in the TAQ data for the day; or (ii) there were not more than 100 TAQ prints and not more than 3000 shares repurchased for the day.[34] This exhaustive searching identifies 504 trades. These must be repurchases if the firms provided accurate disclosure. All transaction-specific tests are replicated on this smaller exhaustive subset; while the power of the tests decline, all results are qualitatively the same.

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[34] The 3000-share requirement limits the search to combinations of not more than 30, as prints are reported on TAQ in round lots of 100 shares. The choice of a maximum complexity level of 30 for the exhaustive search is dictated by computing constraints.

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