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Stealth trading and volatility

Which trades move prices?

Michael J. Barclay and Jerold B. Warner*
University of Rochester, Rochester, NY 14627, USA

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We examine the proportion of a stock's cumulative price change that occurs in each trade-size category, using transactions data for a sample of NYSE firms. Although the majority of trades are small, most of the cumulative stock-price change is due to medium-size trades. This evidence is consistent with the hypothesis that informed trades are concentrated in the medium-size category, and that price movements are due mainly to informed traders' private information.

Key words: Microstructure; Volatility; Insiders; Volume; Efficiency

1. Introduction and summary

This paper raises the issue of informed investors' trade-size choices, and focuses on the implications of these choices for stock-price movements, or volatility. Recent empirical research shows that volatility is caused primarily by private information revealed through trading [French and Roll (1986), Barclay, Litzenberger, and Warner (1990)]. Our main tests examine the proportion of the cumulative stock-price change that occurs in each trade-size category for a sample of New York Stock Exchange (NYSE) stocks. If informed investors' trades are the main cause of stock-price movements, this procedure should allow us to infer the sizes of their trades.

Correspondence to: Jerold B. Warner, William E. Simon Graduate School of Business Administration, University of Rochester, Rochester, NY 14627, USA.

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For a typical sample stock, the majority of trades are small (defined here as 100 to 400 shares). We argue, however, that informed traders will concentrate their trades in medium sizes (500 to 9,900 shares). Under plausible conditions facing these investors, medium-size accumulations will be executed in a single trade, large accumulations (10,000 shares or more) often will be broken up into several medium-size trades, and small accumulations can be ignored. Although only suggestive, this argument is generally consistent with direct evidence for one class of informed traders, corporate insiders [see Jaffe (1974), Meulbroek (1992), and Cornell and Sirri (1992)].

Our central hypothesis is that if privately informed traders concentrate their trades in medium sizes, and if stock-price movements are due mainly to private information revealed through these investors' trades, then most of a stock's cumulative price change will take place on medium-size trades. We label this joint hypothesis the stealth trading hypothesis. This label reflects the existing theoretical literature [e.g., Kyle (1985)], which argues that profit-maximizing informed investors attempt to camouflage their information, for example by spreading trades over time. Our predictions are more general, however, because we incorporate new considerations facing informed investors, such as wealth constraints. These considerations are sufficient to generate the predictions, even in the absence of any camouflaging attempts.

Our tests focus on a sample of tender-offer targets. These firms have large abnormal price increases, on average, before the initial tender-offer announcement. In addition, there is reason to believe that some traders have valuable private information during the preannouncement period. Such a period thus provides a good testing ground for our predictions.

Results for the preannouncement period support the stealth trading hypothesis. Medium-size trades are responsible for an estimated 92.8% of the cumulative price change during this period; none of the cumulative price change occurs on small trades. These results are inconsistent with the predictions of alternative hypotheses. For example, under the hypothesis that most stock-price changes are caused by public information releases, the percentage of the cumulative price change that occurs in a given trade-size category will be directly proportional to the percentage of transactions in that category. This prediction is rejected. Further, the results are not sensitive to our choice of measurement procedures, and do not appear to be driven by any mechanical features of trading or trade reporting.

The stealth trading hypothesis should be applicable beyond the preannouncement period. Thus, we also investigate our sample firms before they exhibit systematic unusual behavior. In addition, we examine all NYSE firms in the 1981–1984 period. In both cases, the results are consistent with the stealth trading hypothesis, although weaker than for the tender-offer preannouncement period.

Section 2 discusses the theoretical motivation for our empirical tests. Section 3 describes the sample and presents data on trading frequency and trade sizes. Section 4 contains the main tests. Section 5 examines the sensitivity of the results to a variety of economic and measurement considerations. The conclusions are in section 6.

2. Motivation, theory, and testable propositions

2.1. Motivation

In theoretical models of informed investors' behavior, these investors attempt to camouflage their trades by spreading them over time [Kyle (1985)] or by trading when liquidity volume is high [Admati and Pfleiderer (1988)]. In most of these models, however, the choice of trade size is not addressed.[1] Empirical studies of informed investors' behavior [e.g., Jaffe (1974)] also ignore trade sizes, and focus on stock-price behavior around these investors' trades.

A reexamination of the data from the empirical studies, however, reveals a striking pattern. Although the data are limited to the insider trading context, they indicate that informed traders concentrate their trades in the medium-size category (500 to 9,900 shares). In Cornell and Sirri's (1992) case study of an insider trading prosecution involving 38 traders, 78.2% of the insider trades are of medium size, compared with only 38.4% of all trades in the same stock.[2] For a large sample of firms with insider trading prosecutions, Meulbroek (1992, p. 1692) reports that the median daily insider share accumulation represents 11.3% of total volume, corresponding to roughly 2,000 shares for a typical NYSE firm in 1984. For trades reported by officers and directors, Jaffe (1974) reports that the median daily trading activity is between $10,000 and $20,000.[3]

The remainder of section 2 first outlines the intuition underlying informed investors' behavior. We then develop the paper's testable propositions and discuss the selection of an appropriate sample.

[1] An exception is Easley and O'Hara (1987).

[2] The fraction of insider trades in the small and large categories is 18.5% and 3.2%, respectively, compared with 60.0% and 1.6% for all trades in the same stock. The insider trade-size percentages are based on the Cornell and Sirri data appendix. The overall trade-size percentages are from the Fitch Intraday Tape for 1981, the last full year prior to the illegal insider trading, and exclude opening trades.

[3] Although Meulbroek and Jaffe do not report individual trades, private correspondence with Meulbroek indicates that most trades in her sample fall in the medium-size category for those cases where the data are available.

2.3. Informed investors' trade-size choices: Theory

Given private information about a security, an informed investor must jointly decide on 1) total share position and 2) whether and how to break up his trades. We ignore other aspects of stealth trading, such as the use of options [see John, Koticha, and Subrahmanyam (1992)] or the use of limit rather than market orders.

Total Share Position. An informed trader's share position will depend on a number of risk and portfolio considerations. In Kyle's (1985) model, the informed trader takes large share positions. He trades until the share price reaches its full with-information value. This analysis assumes, however, that the trader is risk-neutral, has unlimited access to capital, and has private information about only one security.

When these assumptions are relaxed, it seems likely that the share position will be smaller. Uncertainty about the true value of the share will reduce the size of the trader's position if he is risk-averse. Moreover, when the trader follows multiple securities, wealth limitations and constraints on borrowing and short-selling will reduce the size of the share position in any one stock. In the subset of cases in which trading on private information is illegal, the possibility of detection and prosecution will further limit the position.

It is difficult to quantify precisely the effect of these various considerations on the distribution of informed traders' share positions. It seems unlikely, however, that traders with valuable private information will limit their total trading activity to small positions (100 to 400 shares) because the profit potential from these positions is small. Some individual traders will find that their risk aversion and total wealth constraints limit them to share positions of medium size (500 to 9,900 shares). Other traders, such as large institutional investors, will find these considerations less important, and will take large share positions (10,000 shares or more). Thus, the distribution of share positions by informed investors will consist of medium and large sizes.

Breaking Up Trades. Whether an informed trader reaches his desired share position in one or multiple trades should depend on two factors. The first is the expected price impact of the trades (i.e., price concessions). Price concessions include a temporary component as compensation for the specialist or other intermediary for providing liquidity, and a permanent component reflecting any new information revealed by the trade. Both of these components increase with trade size, raising the possibility that a given position can be obtained with a smaller price concession if the trades are broken up and spread over time [i.e., Kyle (1985)].

An offsetting cost is that spreading trades over time delays the acquisition of the desired position and increases the likelihood that the price will move against the trader if his information is revealed publicly or by other informed trades. In addition, most brokerage commission schedules have a fixed cost per trade, which further shifts a trader's strategy in favor of one trade.

Medium share positions are likely to be achieved in a single trade because the price concession for a medium-size trade is small. For example, the NYSE Fact Book (1991, p. 20) reports that the average stock showed no change or a 1/8 point price change in 3,000 shares of volume 84.4% of the time. Thus, any potential reduction in price concessions is unlikely to offset the delay costs from breaking up a medium-size trade.

Large share positions are likely to be broken up, however, because the price concession for a large trade by an informed trader is substantial. The market for large block trades, also known as the upstairs market, is characterized by a lack of anonymity [Keim and Madhavan (1991)]. In this market, uninformed traders have incentives to reveal their identities to reduce the information-related price concessions associated with their trades. If a large-block trader cannot be certified as a liquidity trader, he faces a large price concession.[4] Thus, we hypothesize that an informed trader can achieve a large change in share position with a significantly smaller total price concession through several medium-size trades spread over time. In many cases, the savings from smaller price concessions on medium-size trades will offset any delay costs. The small price concessions for medium-size trades make it unlikely, however, that these trades will be broken up any further.

If informed traders generally achieve large share positions through multiple medium-size trades, and achieve medium share positions in a single trade, then these traders will concentrate their trades in medium sizes. As discussed earlier, evidence from the insider trading literature is consistent with this prediction.[5]

2.3. Testable propositions: The stealth trading hypothesis

Recent empirical research shows that cumulative stock-price movements (i.e., volatility) are due largely to private information revealed through trading, rather than to public information releases [e.g., French and Roll (1986), Barclay, Litzenberger, and Warner (1990)]. Under the joint hypothesis that privately informed traders concentrate their trades in medium sizes, and stock price movements are due mainly to private information revealed through trading, most of a stock's cumulative price change over a given period should take place on medium-size trades. Our tests focus on this empirical prediction. We refer to the joint hypothesis underlying the prediction as the stealth trading hypothesis.

[4]Scholes (1972) and Mikkelson and Partch (1985) show that the identity of the seller has a significant effect on the price impact of secondary distributions. Sales by officers and directors, who presumably have access to inside information, have larger negative price effects than sales by outsiders.

[5]In the Cornell and Sirri (1992) and Meulbroek (1992) samples, positions at the upper end of the medium range (i.e., 5,000–9,900) sometimes involve multiple trades, but these trades are generally of medium size.

Equilibrium and Microstructure. The literature on market microstructure and large-block trades [e.g., Easley and O'Hara (1987), Holthausen, Leftwich, and Mayers (1987)] shows that price concessions increase with trade size. This reflects a positive equilibrium relation between trade size and the probability that an order is initiated by an informed trader. This positive relation can also exist under the stealth trading hypothesis if the ratio of informed to uninformed trades is low, but increases with trade size. Consistent with our earlier discussion, medium-size trades will have small price concessions under these conditions, because informed trades represent only a small fraction of these trades.[6]

The central predictions of the stealth trading hypothesis, however, concern the proportion of cumulative price movement across all trades of a given size, rather than the price impact of a given trade. This takes into account not only the average price concession per trade of a given size, but also the frequency distribution of trade sizes. Knowledge of this distribution is necessary to assess the relative role of different trade-size categories in cumulative price movements.

Alternative Hypotheses. If volatility is caused by private information revealed through trading, our empirical procedures allow us to infer the distribution of informed trades, whatever it is. Furthermore, the empirical implications of the stealth trading hypothesis differ from those under plausible alternative hypotheses about the causes of volatility. These alternative hypotheses provide a benchmark against which to test our central predictions.

As discussed later, one alternative hypothesis is that stock-price volatility is due to public information. As long as public announcements do not affect the distribution of trade sizes, the likelihood that the stock-price change associated with a public information release will occur on a trade of a given size is directly proportional to the relative frequency of that trade size. Thus, under the public information hypothesis, the percentage of the cumulative price change occurring in a given trade-size category is directly proportional to the percentage of transactions in that category. In contrast, the stealth trading hypothesis implies that the proportion of the cumulative price changes occurring on medium-size trades should be higher than the proportion of transactions in that category.

2.4. Sample selection

Our empirical work focuses on a sample of tender-offer targets. The tender-offer sample should provide a good environment in which to test the stealth trading hypothesis. These firms have large abnormal price increases, on average,

[6] To illustrate, let informed trades in the small, medium, and large categories be 0, 10, and 2, respectively, and the corresponding uninformed trades be 100, 75, and 10. Thus, most informed trades are of medium size, but the probability that the trade is informed increases with trade size and is only 10/85 for a medium-size trade.

before the initial tender offer announcement. In addition, there is reason to believe that some traders have private information during the preannouncement period.

Private information can come from both legal and illegal sources. Jarrell and Poulsen (1989) argue that information is revealed by bidders legally acquiring a toehold stake in the company and by professional traders and arbitragers with superior skill in monitoring corporations and their executives. Meulbroek (1992) and Cornell and Sirri (1992) document trades by insiders who are later prosecuted for illegal trading prior to tender-offer announcements.

Our predictions also apply to firms not undergoing such an extraordinary event. Thus, for the tender-offer sample, we examine a period long before the sample firms exhibit unusual behavior. Second, we repeat the tests for all NYSE firms. In both cases, we expect weaker results than for the preannouncement period. The preannouncement period is characterized by unusually large stock-price movements per unit of time, and the movements are probably related to informed trading. In other periods, however, the fraction of stock-price movements due to other factors, such as marketwide movements, is likely to be higher, and the fraction due to informed trading is thus likely to be lower.

3. Sample description

The sample consists of all NYSE firms that were tender-offer targets between 1981 and 1984. There are 108 tender offers involving 105 different target firms.

3.1. Event study results

Fig. 1 presents the cumulative average abnormal stock returns from 200 days before through 20 days after the initial *Wall Street Journal* announcement of the tender offer. The abnormal returns are calculated as prediction errors from the market model regression of the firm's continuously compounded stock return on the continuously compounded return on the Center for Research in Security Prices (CRSP) equally-weighted index with dividends. The market model estimation period includes event days -440 to -201. Cumulative abnormal returns over the two-day tender-offer announcement period including both the *Wall Street Journal* announcement day and the preceding day average 15.0%. These returns are similar to those found by previous researchers [see Jensen and Ruback (1983) for a survey].

More importantly for this study, about half of the total stock-price run-up associated with these tender offers occurs before the first public announcement of the offer. Much of our subsequent analysis focuses on the preannouncement period from day -30 through day -2. During this period, the cumulative abnormal stock returns average 16.3%. To isolate the effects of private

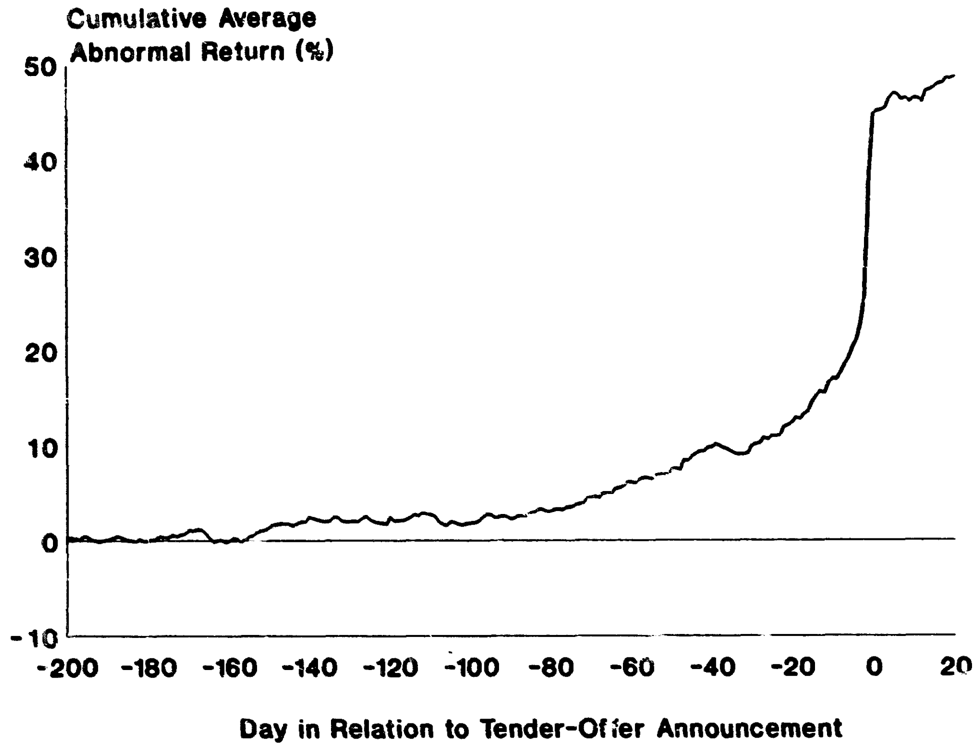

Fig. 1. Cumulative average abnormal stock returns from 200 days before through 20 days after the initial tender-offer announcement for 108 New York Stock Exchange firms between 1981 and 1984.

information revealed through trading from the effects of public information releases, we exclude all days on which these firms are mentioned in the *Wall Street Journal* and the preceding day. These days excluded, the preannouncement period cumulative abnormal returns average 9.0%, with a median of 7.2%; the cumulative average price change is $1.95, with a median of $1.25.

3.2. Changes in trading volume associated with tender-offer announcements

Fig. 2 shows the trading activity associated with the tender-offer announcements. The upper panel reports the mean and median number of transactions per day from event day − 100 to day + 20; the lower panel reports the mean and median share volume per day over the same interval.

The tender-offer announcements are associated with significant increases in both the number of transactions per day and daily share volume. Over the period from event day − 200 to day − 100, which we define throughout this paper as the nonevent period, the median firm averages 18.4 transactions per day, with an average daily volume of 19,284 shares. During the preannouncement period (days − 30 through − 2), the average number of daily transactions increases by over 50% to 28.8, and average daily volume increases to 31,940 shares. On the announcement day, the median firm has 113 trades, generating a volume of 260,200 shares.

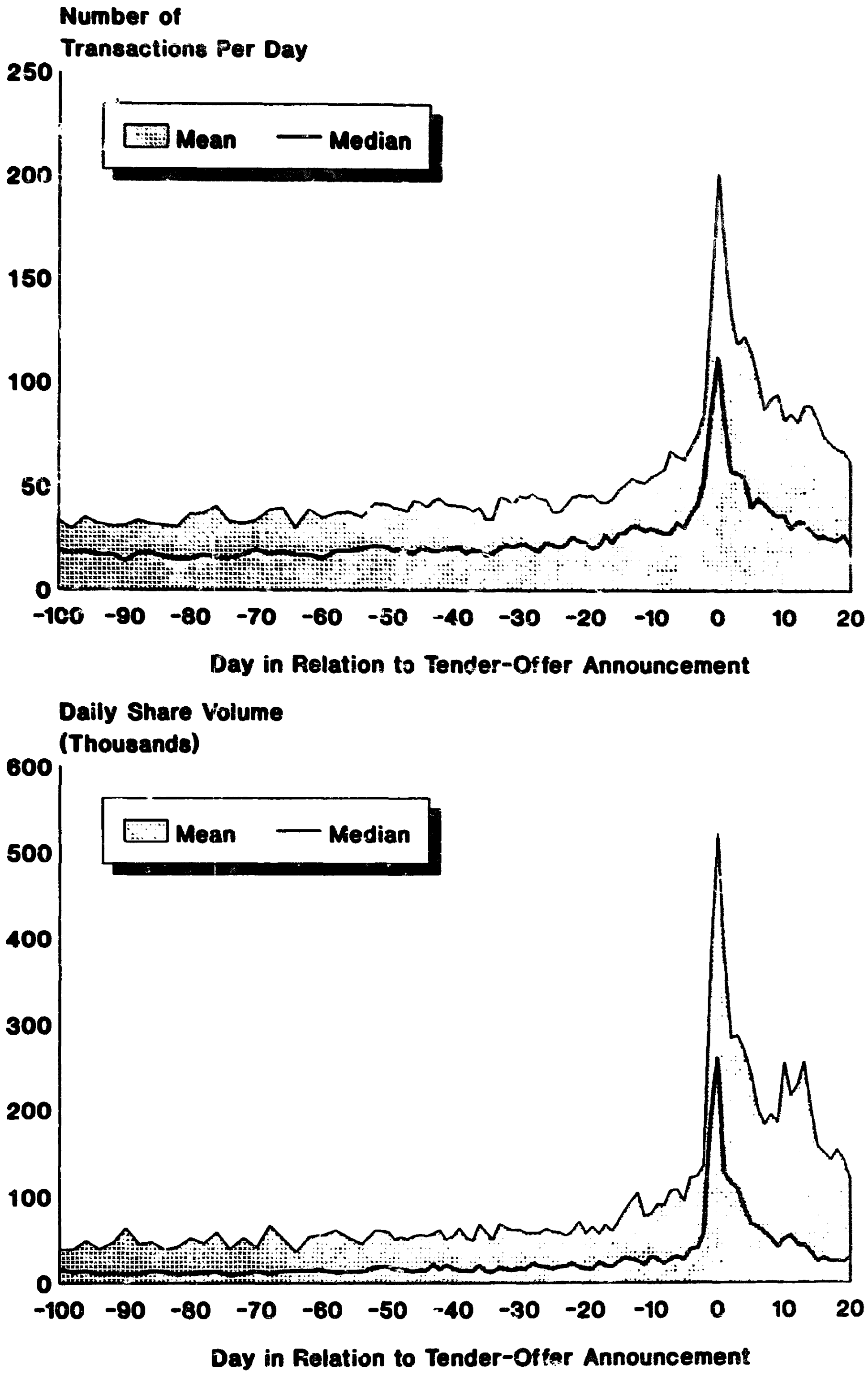

Fig. 2. Measures of trading activity from 100 days before through 20 days after the initial tender-offer announcement for 108 New York Stock Exchange firms between 1981 and 1984; mean and median number of transcations (upper panel) and mean and median share volume (lower panel) per day.

Table 1

Time-series behavior of daily share volume and number of trades for individual securities, by size of trade. Sample: 108 NYSE tender offer targets from 1981 through 1984. Event day 0 is the date of the first tender-offer announcement in the *Wall Street Journal*.[a]

Trade size (shares)		Mean number of trades per day	Percent of trades	Mean share volume per day
	Panel A: Event days −200 through −100			
Small	100	5.34	28.47%	534
	200	2.88	17.33	576
	300	1.50	8.85	451
	400	0.89	4.98	355
Medium	500	1.66	11.37	831
	600–900	1.12	6.50	811
	1,000–1,900	2.00	11.95	2276
	2,000–4,900	0.92	5.48	2494
	5,000–9,900	0.28	1.53	1766
Large	10,000 and over	0.16	0.82	3752
	Total	17.43	100.00	17656
	Panel B: Event days −30 through −2			
Small	100	7.37	22.81%	736
	200	4.65	15.68	929
	300	2.24	7.97	672
	400	1.37	4.63	458
Medium	500	3.60	12.13	1800
	600–900	1.96	6.65	1407
	1,000–1,900	4.07	14.95	4750
	2,000–4,900	1.86	7.05	5093
	5,000–9,900	0.56	2.18	3551
Large	10,000 and over	0.27	1.22	5627
	Total	27.81	100.00	29645

[a]For each firm, the mean number of trades per day and daily share volume are calculated by trade-size category. The table displays the cross-sectional median values of these variables. All days on which these firms are mentioned in the *Wall Street Journal* and the preceding day are excluded.

3.3. Distribution of trade sizes for individual stocks

Table 1 summarizes the distribution of trade sizes for individual sample securities. For the cross-section of securities, the table displays median values of selected firm-specific variables. Panel A reports results for the nonevent period, and panel B reports results for the preannouncement period.[7] Generally, small

[7]Tables 1 through 5 exclude the opening trade of the day. This issue is discussed in section 5. Two sample firms also had zero cumulative within-day price changes during the preannouncement period. These firms are excluded when we calculate percentages of the cumulative price change in tables 2, 3, and 5.

trades predominate, and the total number of trades for the typical sample firm is surprisingly low. This suggests severe constraints on a trader's ability to transact in quantity without the flow of trades appearing abnormal and price changes occurring.

Typical Trade Size and Frequency. From panel A, in the nonevent period the most frequent trade sizes are 100 and 200 shares for the median sample firm, with these categories typically accounting for 28.4% and 17.3% of all trades. During one trading day, the median sample firm averages 5.3 trades of 100 shares and 2.8 trades of 200 shares; the median trade size is 300 shares. Large trades are relatively infrequent for the typical firm, however, averaging 0.16 (0.82%) per day.

Differences among Firms. For most firms, panel A provides an accurate picture of the frequency distribution of trade sizes. The percentage of firms with median trade sizes of 200, 300, 400, 500, and 600 shares is 36.1, 29.6, 17.6, 15.8, and 0.9. The mean number of transactions per day is more variable, ranging from 2.8 to 288.[8]

The general picture in panel A is also representative of NYSE securities in general during the sample period. The typical mean number of trades per day during the preannouncement period is 17.4, compared with 17.8 for all NYSE firms in 1984. For all NYSE firms in 1984, the percentage of firms with median trade sizes of 100, 200, 300, 400, 500, and 600 or more shares is 0.1, 19.9, 31.3, 18.3, 22.8, and 7.5.

Transactions in the Preannouncement Period. Panel B provides a description of trading patterns in the preannouncement period. During this period, trades in every size category increase. On average, however, transactions are only slightly larger in the preannouncement period than in the nonevent period. For the typical firm, the median trade size increases from 300 to 400 shares in the preannouncement period. The proportion of trades in each trade-size category from 100 through 400 shares is smaller, and the proportion of trades in each trade-size category of 500 shares or more is larger.

4. Baseline results

4.1. Sources of cumulative price changes: Description

Our chief concern is how much of a security's cumulative price change in the preannouncement period is attributable to trades in each trade-size category. We define the trade-size categories as small (100 to 400 shares), medium (500 to

[8]The cross-sectional mean number of transactions in each size category is higher than the median values in table 1, but the percentage of transactions by size category is similar with means or medians.

Table 2

Mean percentage of the cumulative stock-price change, percentage of trades, and percentage of share volume by trade size. Summary results for trades classified as small (100 to 400 shares), medium (500 to 9,900 shares), and large (10,000 shares and over) are in bold. Sample: [illegible] NYSE tender-offer targets from 1981 through 1984. Time period: days − 30 through − 2 in relation to first tender-offer announcement in the *Wall Street Journal*.[a]

Trade size (shares)		Percent of cumulative change		Percent of trades		Percent of volume	
	100		− 10.40		23.96		2.99
Small	200	**−2.3**	9.68	**52.6**	15.76	**12.1**	3.90
	300		3.42		8.12		2.98
	400		− 4.99		4.72		2.21
	500		22.87		12.71		7.26
	600–900		1.22		6.86		5.62
Medium	1,000–1,900	**92.8**	38.27	**45.7**	15.17	**63.5**	17.89
	2,000–4,900		23.05		8.12		19.24
	5,000–9,900		7.38		2.88		13.53
Large	10,000 and over	**9.5**	9.50	**1.7**	1.68	**24.4**	24.38

[a]The percentage of the cumulative price change for a given firm is the sum of all stock-price changes occurring on trades in a given size category divided by the total cumulative price change over the (− 30, − 2) period. The table reports the weighted cross-sectional mean of these percentages with weights equal to the absolute value of the cumulative price change over the period. The percentage of trades and percentage of volume are simple (unweighted) averages. Opening trades and close-to-open price changes are excluded from all calculations. All days on which these firms are mentioned in the *Wall Street Journal* and the preceding day are excluded.

9,900 shares), and large (10,000 shares and over). Because these definitions are somewhat arbitrary, we replicate all the tests with ten subcategories (100, 200, 300, 400, 500, 600–900, 1,000–1,900, 2,000–4,900, 5,000–9,900, and 10,000 and over). The results using the subcategories are qualitatively similar, and are omitted from some of the later tables.

Descriptive data on the percentage of the cumulative price change in each trade-size category are presented in table 2. For the cross-section of securities, table 2 reports the mean percentage of the cumulative price change occurring on trades in each trade-size category. We use the following estimation procedure. We define the stock-price change that occurs on a given trade as the difference between that trade's price and the price of the previous trade. For each firm in the sample, we sum all stock-price changes that occur on trades in a given size category during the preannouncement period. We then divide this sum by the cumulative price change during the preannouncement period. We exclude all days on which these firms are mentioned in the *Wall Street Journal* and the preceding day. Finally, we estimate the weighted cross-sectional mean, which is reported in the table.

The weights we use in estimating the cross-sectional means are equal to the absolute value of the cumulative price change over the preannouncement period. Since the variable of interest is the price change summed over all trades in a given trade-size category divided by the cumulative price change, the heteroskedasticity in this variable can be severe, especially for firms with small cumulative price changes. For example, suppose a firm has only a 1/8 point cumulative price change, which is the sum of a 1/8 point price change in each of the small- and medium-size categories, and a $-1/8$ point price change in the large-size category. In this case, the estimated percentage of the cumulative price change in each category will be plus or minus 100%. These percentages are very noisy estimates of the expected proportion of the cumulative price change in each category. Weighting the cross-sectional observations by the absolute cumulative price change significantly reduces the heteroskedasticity in these percentages. In section 5, we examine the sensitivity of these results to the definition of the price changes and to the procedures used to weight the observations.

From table 2, most of the cumulative price change occurs on medium-size trades; trades in this category are responsible for an estimated 92.8% of the cumulative price change, but only 45.7% of transactions and 63.5% of volume. The subcategory with the largest effect is that of 1,000–1,900 shares. These trades account for 38.2% of the cumulative price change, but only 15.1% of all transactions.

In contrast, the small and large categories have relatively little role in the cumulative price change. Small trades account for an estimated -2.3% of the cumulative price change, and large trades account for only 9.5%.[9]

4.2. Sources of cumulative price changes: Formal tests

In this section, we compare the predictions of the stealth trading hypothesis with those of two alternative hypotheses. These alternative hypotheses also make specific predictions about the relation between the percentage of the cumulative stock-price change and the percentage of transactions or total trading volume in each trade-size category. Since these predictions contrast with those of the stealth trading hypothesis, they provide an interesting benchmark against which to measure the importance of the stealth trading hypothesis.

The Public Information Hypothesis. One alternative to the stealth trading hypothesis is the hypothesis that most stock-price changes are caused by the release of public information. As long as public announcements do not affect the

[9]Formal tests in table 5 indicate that these figures are not significantly different from zero. However, the figure for 100-share trades is significantly negative. In section 5.2, we reject the hypothesis that the negative figures are caused by temporary price effects of large trades.

Table 3

Weighted-least-squares regressions of the percentage of the cumulative price change occurring in each trade-size category on dummy variables for the trade-size categories, the percentage of transactions, and the percentage of share volume occurring in that category. The weights are equal to the absolute cumulative price change over the event window. Sample: 106 NYSE tender-offer targets from 1981 through 1984. Time period: days − 30 to − 2 in relation to first tender-offer announcement in the *Wall Street Journal*.[a]

	Regression (1)	Regression (2)
Trade size		
Small (100–400 shares)	− 45.67	− 9.30
	(− 1.14)	(− 0.58)
Medium (500–9,900 shares)	53.63	54.08
	(2.63)	(2.44)
Large (10,000 + shares)	8.08	− 5.91
	(0.87)	(− 0.76)
Percent of transactions	0.84	
	(0.88)	
Percent of volume		0.61
		(0.96)
Adj. R^2	0.11	0.11
F-value	11.22	11.26
Tests on dummy variables	One-tailed p-value	One-tailed p-value
Small = Medium	0.001	0.051
Large = Medium	0.168	0.029

[a]All days on which these firms are mentioned in the *Wall Street Journal* and the preceding day are excluded. t-statistics are given in parentheses.

distribution of trade sizes, the likelihood that the stock-price change associated with a public information release will occur on a trade of a given size is directly proportional to the relative frequency of that trade size.[10] Thus, under the public information hypothesis, the percentage of the cumulative price change occurring in a given trade-size category is directly proportional to the percentage of transactions in that category.

Regression (1) in table 3 reports the weighted-least-squares regression of the percentage of the cumulative price change occurring in each trade-size category

[10]Trade sizes appear to increase slightly around earnings announcements [Lee (1992)] and new equity issue announcements [Barclay and Litzenberger (1988)], but such firm-specific public information releases are infrequent.

on dummy variables for each category and the percentage of all transactions occurring in that category. The regression is pooled across all sample firms, and estimated over the preannouncement period. Under the public information hypothesis, the coefficient on each dummy variable in the regression should be zero, and the coefficient on the percentage of transactions in the trade-size category should be one. As in section 4.2, we weight each observation by the absolute cumulative price change for that firm over the entire event window to reduce the heteroskedasticity in the dependent variable.

The results in regression (1) are not consistent with the public information hypothesis. The hypothesis that the coefficient for the percentage of transactions is equal to one can be rejected at the 0.001 level of significance. The hypothesis that all of the dummy variables are equal to each other can also be rejected at the 0.001 level.

The data indicate that the percentage of the stock-price change is smaller than predicted by the public information hypothesis in the small-trade-size category, and larger than predicted in the medium-trade-size category. The coefficients are – 45.7 and 53.6, respectively. The hypothesis that the coefficient in the small-trade-size category is equal to the coefficient in the medium-trade-size category can be rejected at the 0.001 level of significance. Although the estimated coefficient on large trades is much smaller than the coefficient on medium trades, the hypothesis that these coefficients are equal can only be rejected at the 0.168 level of significance. These various results are not consistent with the public information hypothesis, but they are consistent with the stealth trading hypothesis.

Stock-price Changes and Trading Volume. Both the theoretical and the empirical literature on large-block trades suggest that a large trade moves the price more than a small trade. The precise relation between stock-price changes and trading volume is not specified, but we examine the most straightforward case, where the price change on a trade is directly proportional to the trade size. Thus, an additional 1,000 shares purchased would have the same cumulative effect on the price of the stock regardless of whether the shares were purchased in one trade or in ten 100-share trades. In this case, the percentage of the cumulative price change in each trade-size category should be proportional to the fraction of the total trading volume in that category.

Regression (2) in table 3 reports the weighted-least-squares regression of the percentage of the cumulative price change occurring in each trade-size category on dummy variables for each trade-size category and the percentage of the total trading volume occurring in that category. Estimation procedures are the same as those used in regression (1).

The results in regression (2) are not consistent with the hypothesis that cumulative price changes are proportional to trading volume. The joint hypothesis that the dummy variables are all equal to zero and the coefficient on the percentage of trading volume is equal to one can also be rejected at the 0.001 level of significance. The hypothesis that all of the dummy variables are equal to each other can also be rejected at the 0.001 level. Again, the medium-trade-size category accounts for a greater fraction of the cumulative price change than would be predicted by its share of trading volume. The hypothesis that the coefficient in the small-trade-size category is equal to the coefficient in the medium category can be rejected at the 0.051 level of significance. The hypothesis that the coefficient in the medium-trade-size category is equal to the coefficient in the large-trade-size category can also be rejected to the 0.029 level of significance. Although we do not view this as a strong test of the stealth trading hypothesis against a general alternative in which price changes are related to trading volume, the results of this regression are consistent with the stealth trading hypothesis.

4.3. Results for the nonevent period

It is also of interest to examine the stealth trading hypothesis for the nonevent period, from day -200 to day -100. Stock-price performance over this period is not systematically abnormal. The average cumulative abnormal return for our sample firms is 1.8%, which is not significantly different from zero, and the average cumulative stock-price change is only \$0.86. Nevertheless, individual cumulative price movements are generally large, as would be expected given the length of the period and typical daily return variances. The average absolute price change over this interval is \$5.04, which is larger than the average absolute price change of \$2.62 on nonannouncement days during the preannouncement period.

Unlike in the preannouncement period, we do not expect the cumulative price movements in the nonevent period to be due primarily to one firm-specific event. Rather, they reflect a series of firm-specific events, as well as the implications of economywide developments for the firm. If the stealth trading hypothesis is applicable to such a period, however, most of a security's cumulative price movement will still occur on medium-size trades.

Table 4 reports the mean percentage of the cumulative stock-price change by trade-size category for the nonevent period. The estimation procedures are the same as those in table 2. The results are remarkably similar to those for the preannouncement period. Medium-size trades account for 99.4% of the cumulative stock-price change during the nonevent period, but only 38.1% of all transactions and 58.2% of total trading volume. As in the preannouncement period, trades in the 1,000–1,900 share category make the largest contribution. These trades account for 30.9% of the cumulative stock-price change, but only 12.4% of transactions and 17.4% of trading volume. Thus, it appears that the stealth trading hypothesis has explanatory power outside of the tender-offer context.

Table 4

Mean percentage of the cumulative stock-price change, percentage of transactions, and percentage of share volume by trade size for a nonevent period. Summary results for trades classified as small (100 to 400 shares), medium (500 to 9,900 shares), and large (10,000 shares and over) are in bold. Sample: 108 NYSE tender offer targets from 1981 through 1984. Time period: days − 200 through − 100 in relation to first tender-offer announcement in the *Wall Street Journal*.[a]

Trade size (shares)		Percent of cumulative price change		Percent of trades		Percent of volume	
Small	100	**−10.4**	−23.69	**60.6**	29.18	**16.2**	4.34
	200		−5.95		17.27		5.01
	300		10.46		8.94		3.86
	400		−8.78		5.19		2.99
Medium	500	**99.4**	27.51	**38.1**	11.48	**58.2**	7.79
	600–900		15.83		6.76		6.58
	1,000–1,900		30.94		12.42		17.41
	2,000–4,900		16.30		5.65		16.08
	5,000–9,900		8.85		1.81		10.32
Large	10,000 and over	**11.0**	10.99	**1.3**	1.30	**25.6**	25.61

[a]The percentage of the cumulative price change for a given firm is the sum of all stock-price changes occurring on trades in a given size category divided by the total cumulative price change over the (− 200, − 100) period. The table reports the weighted cross-sectional mean of these percentages with weights equal to the absolute value of the cumulative price change over the period. The percentage of trades and percentage of volume are simple (unweighted) averages. Opening trades and close-to-open price changes are excluded from all calculations.

Regression Results for the Nonevent Period. Regressions for the nonevent period (not reported here) are qualitatively similar to those for the preannouncement period, although the results are somewhat weaker. These regressions reject both the public information hypothesis and the hypothesis that cumulative price changes are proportional to trading volume, in favor of the stealth trading hypothesis.

Parameter estimates in the nonevent period regressions, however, are much noisier than those for the preannouncement period. In particular, regressions including the number of transactions appear misspecified in the nonevent period. Although the parameter estimate is larger in the medium-trade-size category than in the small- or large-trade-size categories, as predicted by the stealth trading hypothesis, all of the dummy variables are negative.

Some of the difficulty in estimating these regressions for the nonevent period appears to come from extreme observations associated with firms that have small cumulative stock-price changes. Even though these firms receive smaller weights in the regressions, they seem to add considerable noise. We discuss the sensitivity of our results to extreme observations in section 5.1.

5. Additional economic and measurement issues

This section examines the robustness of the findings in section 4 to several economic and measurement considerations. Although the general conclusions are unchanged, this sensitivity analysis highlights a number of issues in specifying and testing the stealth trading hypothesis.

5.1. Observations with small or negative price changes

In sections 4.2 and 4.3, we focus on the preannouncement period because it appears to contain an unusually large amount of informed trading. The average cumulative price change during this period (excluding overnight periods and all public announcement days) is \$1.73, or 7.1% of the closing price on day − 31; the median price change is \$1.56, or 6.9%. From these figures, it appears *ex post* that our sample firms were undervalued and that informed traders were buying stock during this period.

However, 33 of 108 price changes for our sample firms are negative or zero during this period, and 25 of the within-day price changes are smaller than 4% in absolute value. Since the sample firms generally experience large positive price changes on the tender-offer announcement days, firms with small or negative price changes during the preannouncement period either have little informed trading, or the stock-price increases associated with the informed trading are offset by other unfavorable information such as a decline in the market as a whole. These firms are likely to add noise to the regressions in table 3 without providing much information about stealth traders. In the previous section, we addressed this issue by weighting the observations by the absolute value of the cumulative price change. In this section, we examine subsamples that appear to have the most informed trading before a tender-offer announcement. Results for these subsamples generally provide stronger support for the stealth trading hypothesis.

For various subsamples, table 5 reports weighted-least-squares regressions of the percentage of the cumulative price change on dummy variables for each trade-size category. We include only the trade-size dummies (and exclude the number of transactions and trading volume) to focus on the explanatory power of trade size in these regressions. Since the number of trades and trading volume have very little explanatory power in these regressions, excluding these variables does not significantly affect the interpretation of the dummy variable coefficients.

Regression (1) in table 5 is identical to the weighted average percentage of the cumulative price change that is reported in table 2 and is included for comparison purposes. The R^2 in regression (1) indicates that for the sample as a whole, 11.5% of the variance of the percentage of the cumulative price changes is explained by the dummy variables for the trade-size categories. Regressions (2)

Table 5

Sensitivity of regression results to inclusion of noisy observations. Weighted-least-squares regressions of the percentage of the cumulative price change occurring in each trade-size category on dummy variables for the trade-size categories. The weights are equal to the absolute cumulative price change over the event window. Regression (1) includes all sample firms; regression (2) deletes firms with cumulative price changes less than 4% in absolute value; regression (3) deletes firms with cumulative price changes less than 4%; regression (4) deletes firms where the percentage of the cumulative price change occurring in any category exceeds 300% in absolute value. Sample: 106 NYSE tender-offer targets from 1981 through 1984. Time period: days − 30 to − 2 in relation to the first tender-offer announcement in the *Wall Street Journal*.[a]

		Regression			
		(1)	(2)	(3)	(4)
Trade size					
Small	(100–400 shares)	− 2.30 (− 0.16)	− 7.90 (− 0.73)	− 12.74 (− 1.04)	11.63 (1.42)
Medium	(500–9,900 shares)	92.80 (6.61)	99.47 (9.20)	107.01 (8.77)	79.16 (9.66)
Large	(10,000 + shares)	9.50 (0.67)	8.43 (0.78)	5.72 (0.47)	9.20 (1.12)
Sample size		106	83	66	89
Adj. R^2		0.115	0.249	0.275	0.260
F-value		14.718	28.564	26.089	32.223

[a]All days on which these firms are mentioned in the *Wall Street Journal* and the preceding day are excluded. t-statistics are given in parentheses.

through (4) repeat regression (1), each using a different sample selection criterion.

Regression (2) excludes all firms with cumulative price changes smaller than 4% in absolute value. This reduces the sample to 83 firms. Eliminating the firms with small absolute price changes has little effect on the parameter estimates in the regression, but the adjusted R^2 increases to 24.9%. Regression (3) in table 5 includes only the 66 firms in our sample that have positive price changes larger than 4%. As noted above, firms with negative price changes in the preannouncement period probably have little informed trading and mainly add noise to the regression. Again, the parameter estimates are not significantly affected by the sample selection criterion, but the adjusted R^2 of the regression increases to 27.5%. Finally, regression (4) includes only the 89 firms in the sample that have no single trade-size categories with more than 300% (or less than − 300%) of the cumulative stock-price change. Again, the parameter estimates are not significantly affected by the sample selection criterion, but the adjusted R^2 is 26%.

Nonevent-period regressions using subsamples constructed as in regressions (2) through (4) are not reported. The general pattern is similar to that for the preannouncement period. In particular, when we drop observations for which there is little evidence of informed trading, the R^2s of the regressions increase significantly. Further, extreme observations are more prevalent in the nonevent period, suggesting that there is more noise and less informed trading during this period. For example, there are 29 firms with at least one trade-size category having more than 300% (or less than − 300%) of the total cumulative stock-price change, and 69 firms with at least one trade-size subcategory having more than 100% (or less than − 100%) of the total cumulative stock-price change.

5.2. Temporary versus permanent components of stock-price changes

In estimating the percentage of a stock's cumulative price change occurring on trades of a given size, tables 2 through 5 define the price change associated with a trade as the difference between that trade's price and the price of the previous trade. This procedure allows for temporary components of the price change, so long as they are not systematic. For example, if buy orders go off at the bid price and sell orders at the ask price, trades in every size category will have a temporary price-change component. If there are the same number of buy and sell orders in a given size category, however, these temporary components will average out to zero across all trades in that category.

It is not clear how any bias from ignoring temporary price-change components could drive our results. The direction of any potential bias is difficult to specify without additional assumptions about the magnitude and duration of temporary price-change components, and the frequency and sequence of different size trades on the ticker. A potentially important concern, however, is that the larger the trade, the greater the possibility of systematic temporary price-change components. Larger trades are more likely to move prices because the specialist requires higher compensation for providing liquidity, and the information content is generally higher.[11] Both the liquidity and information-based components of the price change have the same sign, positive for buy orders and negative for sell orders. The liquidity-related component is only temporary, however. Thus, the percentage of the cumulative price change associated with relatively large trades is biased upward if buy orders are more frequent than sell orders in these categories when the cumulative price movement is positive and vice versa.

Trade Sequences. This bias from ignoring temporary price-change components should be most evident in sequences of trades where a relatively large trade precedes a very small trade (e.g., 100 shares). The smallest trades are the most frequent and have the highest likelihood of following large trades. Thus,

[11]For example, in the nonevent period, the cross-sectional median frequency that a trade occurs on a zero tick declines from 54% for 100-share trades to 40% for trades exceeding 9,900 shares. Similar results apply in the preannouncement period.

the smallest trades' estimated percentage of the cumulative price change would be biased downward.

In the preannouncement period, on average 22.5% of the 100-share trades follow trades of 1,000 or more shares. When these 100-shares trades are deleted from our analysis, the estimated percentage of cumulative preannouncement price change occurring on 100-share trades is − 11.1%. This is almost identical to the figure reported in table 2. For the nonevent period, the figure with these 100-share trades deleted becomes − 12.3%. Although this is somewhat higher than the figure reported in table 4, it does not appear that systematic temporary components of price changes seriously bias our results.

Longer Measurement Intervals. As a second check, we redefine the price change associated with a trade to be the price of the first, second, or third subsequent trade minus the price of the previous trade. Using longer measurement intervals is an imperfect adjustment for the temporary price-change components since it incorrectly assigns part of a trade's price change to the surrounding trades. Nevertheless, when we use these alternate price-change definitions, the qualitative results in table 2 are unchanged. Thus, our results do not appear sensitive to the measurement procedure.

5.3. Mechanical features of trading and trade reporting

Trades Reported versus Orders Executed. Trades reported on the tape do not always have a one-to-one correspondence with individual orders [Bronfman (1992 app. A1)]. For example, a 300-share trade reported on the tape could represent the pairing of a market buy order for 300 shares with market sell orders of 100 and 200 shares. Specialists have considerable latitude in how such a transaction is reported.[12] If the sell orders in the above example are filled at the same price, the transaction could be reported as either one or two trades; if the sell orders are filled at different prices, two trades would be reported. When such a transaction is reported as two trades, both have the same minute stamp.

Since we have data only on reported trades and not on underlying orders, appropriate attribution of price moves to underlying orders is not straightforward. Although this is a troubling issue, further investigation suggests that the distinction between trades and orders does not present a major problem. In the preannouncement period, for the median firm an average of only 3.4 trades per day, or roughly 15%, have the same minute stamp. This indicates that very few cases represent a pairing of more than two orders. We caution, however, that the 15% figure understates the true percentage, because it excludes cases in which a market order is paired with a partial fill of a limit order.

[12]This is based on discussions with Exchange officials and specialists, direct observation of specialists' behavior, and examples in Bronfman (1992, sect. A2).

Large-block Trades. When a block of 10,000 shares or more is traded, the NYSE requires that limit orders on the specialist's book receive the benefit of the block price [see Hasbrouck and Sosebee (1992)]. If medium-size limit orders are first in the sequence of reported trades, price moves caused by the large block are incorrectly attributed to a medium-size trade. To examine the importance of this phenomenon, we discard all cases in which two or more trades accounting for 10,000 shares or more have the same minute stamp. The results are unchanged, so it does not appear that the mechanics of large-block trading drive our results.

5.4. Results for all NYSE firms

To provide additional evidence on the generality of the stealth trading hypothesis, we repeat the main tests for all NYSE firms for the years 1981 through 1984. These tests use 5,781 firm-years of data, and are based on each firm's cumulative annual price change in each year. For a firm to enter in a given year, we require 200 or more days with prices.

Table 6 summarizes the results. Both trade-size frequencies and the percentage of cumulative price change occurring in each size category are similar to the percentages shown earlier in table 2 and 4. From table 6, the medium-trade-size category accounts for an estimated 82.9% of the cumulative price change, but only 38.2% of transactions and 55.1% of volume. Thus, medium-size trades still account for the bulk of the cumulative price change, as predicted by the stealth trading hypothesis. Further, 60.2% of all trades are small, but these trades account for only 1.5% of the cumulative price change. Transactions and volume regression results for the NYSE sample are similar to the results for the nonevent period.

From table 6, large trades account for an estimated 16.0% of the cumulative price change. This is larger than the figures of 9.5% and 11.0% reported in tables 2 and 4, even though the percentage of transactions in these categories is roughly 1.5% for all cases. One possible explanation for this finding is related to systematic differences between the NYSE and tender offer samples. For each sample, the median trade size for the typical firm is 300 shares. The NYSE sample, however, contains a number of firms with very large trades. For example, no tender-offer sample firm has a median trade size exceeding 600 shares, compared with 3.6% for the NYSE sample in 1984. For firms with unusually large median trade sizes, the appropriate definition of a medium-size trade changes. This is because the trade sizes in which informed traders concentrate their trades are likely to differ from those for the typical firm, and to be higher when median trade size is high.

To examine this issue, we partition the NYSE sample by median trade size and repeat table 6. Consistent with the previous discussion, the results indicate that informed trade sizes are larger when a stock's median trade size is larger.

Table 6

Mean percentage of the cumulative stock-price change, percentage of trades, and percentage of share volume by trade size for NYSE firms from 1981 through 1984. Summary results for trades classified as small (100 to 400 shares), medium (500 to 9.900 shares), and large (10,000 shares and over) are in bold. Sample size: 5.7 . rm-years.[a]

Trade size (shares)		Percent of cumulative price change		Percent of trades		Percent of volume	
	100		−12.09		28.63		3.87
Small	200	**1.5**	5.99	**60.2**	17.25	**14.5**	4.52
	300		4.50		8.94		3.41
	400		3.14		5.34		2.67
	500		16.85		10.60		6.42
	600–900		6.84		6.99		5.98
Medium	1,000–1,900	**82.9**	24.06	**38.2**	12.20	**55.1**	15.43
	2,000–4,900		22.88		6.22		16.13
	5,000–9,900		12.23		2.15		11.12
Large	10,000 and over	**16.0**	15.58	**1.7**	1.67	**30.5**	30.45

[a]The percentage of the cumulative price change for a given firm is the sum of all stock-price changes occurring on trades in a given size category divided by the total cumulative price change over the (− 30, − 2) period. The table reports the weighted cross-sectional mean of these percentages with weights equal to the absolute value of the cumulative price change over the period. The percentage of trades and percentage of volume are simple (unweighted) averages. Opening trades and close-to-open price changes are excluded from all calculations.

For firms with median trade sizes of less than 500 shares, the percentage price change in the large size category is 13.8%; for firms with median trade sizes of 500 shares or more, the percentage rises to 22.0%. In both cases, however, the bulk of the cumulative price change is still in the medium category.

5.5. *Trading at the open*

We have focused thus far on within-day price changes, and have ignored the period from close through open. Ignoring the opening trade of the day biases downward the figures in table 1 on typical trading volume and transactions. Moreover, opening procedures on the NYSE provide an additional opportunity for a stealth trader. At the opening, all orders accumulated since the previous close are executed simultaneously by the specialist, who sets one price to clear the market. Since the trades thus executed are reported as one trade on the ticker, one possibility is that an informed trader can better conceal his activities from the market by trading at the open.

The fraction of trading volume taking place at the open is significant, but does not increase before a tender offer. In the preannouncement period, the mean percentage of trading volume at the open is 7.38% for the median firm. This is similar to the figure of 9.00% for the nonevent period. Although the absolute level of opening volume increases in the latter period, there is no clear-cut evidence of a shift in opening behavior by informed traders. Moreover, stock-price changes between close and open account for a relatively constant fraction of the cumulative price changes, 11.27% for the nonevent period and 14.42% for the preannouncement period. From these figures, trading at the open does not appear to be any more important just before a tender offer than in a normal period.

6. Conclusions

Using a sample of NYSE tender-offer targets, we find that most of the sample securities' preannouncement cumulative stock-price change occurs on medium-size trades. This evidence is consistent with the hypothesis that informed trades are concentrated in medium sizes and that price movements are due mainly to informed traders' private information. These results appear more general because they also apply to a nonevent period long before the sample securities experience systematic unusual behavior, and to a sample of all NYSE securities.

Although we focus on trade size, institutional features are also relevant to understanding both informed investors' trading strategy and which trades move prices. We have not analyzed these features in detail. For example, we have not examined the differing implications of market and limit orders, although both categories represent a significant fraction of all orders, and informed investors appear to use both [Cornell and Sirri (1992)]. Similarly, an order can be routed to the specialist or to a floor broker, but the choice of order routing and the nature of customer instructions given to a floor broker have not been explored here. A better understanding of these considerations would probably lead to more precise predictions about informed traders' strategy and the implications for stock-price movements.

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