Research Support
School of Business Administration

Nov. 1994

THE VALUE OF TRANSACTION REPORTING

Working Paper #9405-35

Paul J. Seguin
University of Michigan

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Paul J. Seguin*

This Revision: January, 1993

*Assistant Professor, School of Business Administration, University of Michigan, Ann Arbor MI 48109-1234. I wish to thank Mike Barclay, Kalman Cohen, Tom Cooley, Mason Gerety, Tony Greig, Gregg Jarrell, Greg Kadlec, Nancy Kotzian, John Long, Haim Mendelson, Margaret Monroe, Jill Pranger, Bill Schwert, Doug Skinner, Cliff Smith, Bob Whaley, seminar participants at Duke University, the University of Washington and the 26th Western Finance Association Conference. Ming Chi Hu and Arun Kumar provided able research assistance. This research was partially funded by the T. Boone Pickens Jr. Research Fellowship at the Managerial Economics Research Center, University of Rochester.

The Value of Transaction Reporting

Abstract: This study evaluates the importance of the real-time dissemination of recent prices and volumes by examining 2,639 issues that joined the National Market System, thus becoming subject to real-time transaction reporting. On average, transaction reporting is associated with lower daily return volatility, lower required rates of return and smaller bid-ask spreads. These effects occur immediately and the decline in volatility is not entirely attributable to changes in aggregate volatility. Cross-sectional analysis indicates that transaction reporting effects are not homogenous, but are most pronounced for those firms where transactions information is valuable and dispersed.

1. Introduction

This study examines 2,639 common stocks that joined the National Market System (NMS) between April 1982 and September 1987. The principal effect of NMS listing is the introduction of real-time reporting of transaction prices and volumes. Since other aspects of the micro-structure remain unchanged, this examination provides useful insights into the effect of the homogeneity of transaction information.

The results demonstrate that market structure in general and regulations concerning the dissemination of information about recent prices and volumes in particular, can have real effects on asset price behavior. Daily stock return volatilities decline by 8-10% immediately upon the inception of transaction reporting, and statistically reliable declines in bid-ask spreads and required rates of return are documented. Further, these effects are greater for those issues where transaction data is dispersed among many market makers and the information content per trade is high.

These findings are relevant to three areas of financial research. First, this study adds to research that examines the relation between observed volatility and the flow of information. Numerous studies predict that the two are positively correlated (see Karpoff [1987] for a survey). For this sample, the single effect of NMS listing is the introduction of transaction reporting. This lowers the costs of collecting information on recent transactions and prices, enhances the price discovery process and increases liquidity. According to the Securities and Exchange Commission (SEC Release 34-21583):

> Last sale reporting...has provided investors with the benefits of more detailed information concerning executions in the OTC market. In addition, last sale reporting has enhanced market efficiency and increased the public exposure of market information.

Since the greater availability in information is associated with a decline in observed volatility, the results of this study provide a counter-example to the positive relation between information and volatility. However, the results are consistent with the predictions of Schwartz [1988], who argues that "floor information" (information on current market conditions, including recent prices and volumes) enhances the price discovery process, which in turn reduces return volatility.

This study is relevant to a second branch of research: the investigation of the relation between required rates of return and the information environment. Barry and Brown [1984, p. 284] claim:

> ...securities for which there is relatively little information available may be perceived as riskier...and participants in the market may rationally demand a premium to hold such securities.

Amihud and Mendelson [1988, p. 13] argue that listing should result in lower required rates of return, since exchange listing enhances the information environment. This claim, however, is inconsistent with Fabozzi and Hershkoff [1979] and Reints and Vandenberg [1975], who find no significant effects of exchange listing on systematic risk (beta) for their samples of OTC stocks that list on the NYSE and AMEX. In contrast, the analysis of returns conducted here provides strong evidence that required rates of return decrease following the introduction of centralized transaction reporting.

Finally, this study is one of the first to provide empirical evidence on the relation between security performance and market consolidation or centralization. Biais [1991, p. 3] argues that market centralization depends crucially on "the quality of information about market conditions," specifically information about current quotes and recent trades of other market participants. Mendelson [1987] argues that fragmentation increases the variance of prices at which trades can be made, while Biais [1991] concludes that bid-ask spreads, the number of active dealers and market order sizes are invariant with the degree of market consolidation. The empirical results here indicate that centralization appears to have beneficial effects on market performance.

In the following section, background on both the National Market System and transaction reporting is provided. Predicted effects of the introduction of transaction reporting on volatility, spread and required rates of return are generated in Section 3. Sample selection is discussed in Section 4, while Sections 5, 6 and 7 report the results of aggregate tests of the effect of NMS transaction reporting. In Section 8, cross-sectional tests that describe the relation between the informational environment of an issue and the effect of initiating transaction reporting are presented. The final section contains conclusions.

2. Transaction Reporting on the National Market System

The concept of a national market system was introduced by Congress in the Securities Act Amendments of 1975, and subsequently adopted by the National Association of Security Dealers (NASD). By 1990, over 3,000 firms were listed on the exchange, placing it above AMEX in terms of membership, trading volume and dollar volume.

2.1 Transaction Reporting:

Under the auspices of the NASD, the National Market System is designed to compete against the NYSE and AMEX. Structurally, it is a hybrid between the NASDAQ and NYSE systems. Like NASDAQ, the NMS is a communications system, rather than a physically central trading location. Further, it is an inter-dealer market, with few barriers to entry and exit for dealers.

The NMS is like the NYSE, however, in its approach to transaction reporting. For a NASDAQ issue, firm quotes are supplied to the central system by dealers. Though the dealer is obligated to honor his quote for a board lot order, he is free to transact at prices other than those quoted. For example, dealers, attempting to correct inventory imbalances, may trade with each other at prices between the bid and ask. Or, the dealer may choose to trade against a block trader at a price that is worse than the quote. A trader (either directly or through his broker) accesses these quotes via the NASDAQ computer network, identifies the "best" quote (the lowest ask or highest bid), and completes the transaction with this dealer. The dealer is under no obligation to report to traders, other dealers or the NASD that a transaction has occurred. Further, if there are multiple dealers making a market in a particular issue, each dealer will see only those transactions in which he participates. That is, a particular dealer will see only sell orders (if he has the best bid), only buy orders (if he has the best ask), or no orders at all.

If the stock is an NMS issue, the transaction process is identical. However, once the transaction is consummated, the dealer is required to report the transaction via the Computer Assisted Execution System. If the two parties are both dealers, both report the trade: one dealer reports a buy, the other a sale. Within 90 seconds, information concerning the transaction is reported to all dealers and those traders with access to NASD terminals.

2.2 NMS Eligibility:

Joining the National Market System is governed by Rule 11Aa2-1 of the Securities Exchange Act, which defines two categories of listings. The first is mandatory listing, where the decision to join the NMS rests not with the firm, but with the National Association of Security Dealers. Until 1984, the NASD could list any firm that satisfied the volume-related criteria listed in the first column of Table 1. The second category is voluntary listing, where the decision to list rests with firm management. Initially, the criteria for voluntary listing differed from mandatory listing requirements only in terms of minimum price per share: $10 per share for mandatory and $5 per share for voluntary. In December 1984, the criteria for voluntary listing were amended. Under this amendment, an issue must satisfy either of two sets of criteria, outlined in the third and fourth columns of Table 1. The NASD claimed that these new criteria recognized "economic importance" rather than trading volume.

Once a firm is eligible for listing, the NASD forwards the firm name to the SEC for its approval. Though approval is rarely denied, the SEC remains reluctant to list issues that are "too volatile."[1] To maintain listing, an issue must satisfy the substantially less restrictive criteria outlined in the final column of Table 1. In the rare instances when a firm has not met the maintenance requirements, the National Market System may temporarily waive these requirements. A search of the *Wall Street Journal Index* uncovered two instances where maintenance requirements were waived.

For issuers, the decision to join the NMS is straightforward. National Market System listing results in no additional listing fees. However, aside from the introduction of last sale reporting, the perceived benefits of NMS listing include enhanced visibility and market efficiency. Firms joining the NMS after November 12, 1984 have received a second benefit; they become eligible for margin purchases immediately upon NMS listing, thus by-passing the Federal Reserve Board's review process.[2] Prior to the inception of the NMS, these benefits could be realized only after paying the substantially higher fees of a "listed exchange." *Barron's* reports that typical listing costs are $5,000 for an NMS issue versus $30,000 for an NYSE issue. One extreme example is MCI, which paid $7,500 in NMS listing costs for 1984. According to the NASD, their NYSE listing costs for the same year would have been $877,860.

Figure 1 plots the number of NMS listings by month. Many factors affected the flow of listings. The NASD itself wished to expand the NMS as quickly as possible. However, initially member dealers were concerned with the burden of transaction reporting, and sought to limit the flow of listings. By mid-1984, dealers discovered that the burden was not as great as had been forecasted, and dropped their opposition to rapid expansion. In addition to dealer attitudes, the flow of listings was also determined by the stock of eligible firms. With the amendment of Rule 11Aa2-1, effective January 1985, approximately 2,500 firms immediately became eligible to join the NMS. Rather than face an overnight quadrupling in size, the SEC, dealers and the NASD

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[1] I reached this conclusion based on discussions with current and past officials of the SEC. Further, in Release 34-21583, the SEC stated that the NMS was not the place for "low-priced, speculative, 'hot issue' stocks."

[2] Seguin [1990] documents a reduction in volatility for firms granted eligibility under the review process. However, in a previous draft, I found no evidence that the volatility results presented here vary for firms granted automatic eligibility. Details of these tests are available upo request.

agreed to limit the entry of these new firms to avoid "choking the system."[3] The small number of entrants in late 1987 is at least partially due to the October crash, since some firms became ineligible for listing due to an inadequate price per share or market value of equity.

3. Predicted Effects of Transaction Reporting

The primary implication of the introduction of transaction reporting is the reduction in the costs of collecting "floor information." With the introduction of transaction reporting, the information content of recent trades is quickly and uniformly communicated to traders and dealers. Hasbrouck [1988] reports that "the information content of trades...is found to be substantial," while Hasbrouck [1991] concludes that "approximately 34% of the variance in efficient prices is explained by trades." In this section, I discuss how the immediate dissemination of floor information affects three frequently studied attributes of market performance: volatility, required rates of return and liquidity as measured by the bid-ask spread.

3.1 Implications for Bid-Ask Spreads:

Theoretical work on the bid-ask spread, including Cohen *et al* [1986, Ch. 5], Ho and Stoll [1983] and Stoll [1978, 1989], suggests that spreads are comprised of two components: a pure transactions cost that covers the dealer's fixed and variable costs and compensation for trading against traders with potentially superior information. If the introduction of transaction reporting enables dealers to identify informational trading more quickly, their loss to traders with superior information is reduced. Since the expected loss represents a large portion of the spread (Stoll [1989] estimates this proportion as 57%), narrower spreads should result.

If the security is non-NMS, a dealer with the best ask must determine whether he is trading against informed or liquidity–motivated traders, based only on the observed flow of sell orders and the changes in quotes of competing dealers. Once the security becomes NMS, a dealer can observe both buy and sell orders. If the flow of buy and sell liquidity orders is correlated, the probability that the dealer makes the correct inference is higher when buy orders are directly observed.

The problem is symmetric for the dealer with the best bid. Consequently, losses to informed traders and opportunity losses from not trading against liquidity traders are both reduced in a regime of transaction reporting. Since competition between market makers assures that spreads fall when the costs of making a market are reduced, NMS listing should result in narrower quoted spreads.

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[3]This quote is attributed to Gordon S. Macklin, president of the NASD, in the *Wall Street Journal*, November 15, 1984.

There are two cross-sectional implications for the introduction of transaction reporting. First, without transaction reporting, each market maker sees only those transactions in which he took part. Therefore, as the number of market makers increases, each dealer sees a smaller portion of the transactions. Inferences about the existence of traders with superior information are less powerful when the dealer conditions on a smaller information set. So, the introduction of transaction reporting provides comparatively more information in cases where the transaction information was originally dispersed among a greater number of market makers.

Second, the rapid communication of recent transaction information is of value only if these transactions convey information about the intrinsic value of the stock. If we assume that trades can be dichotomized into those involving informed traders and those involving only liquidity traders, then the rapid communication of transactions is of comparatively greater value when the proportion of transactions involving informed traders is large. Consequently, the introduction of transaction reporting is of greater importance when each trade contains a higher informational content.

3.2 Implications for Volatility and Required Rates of Return:

A commonly employed class of models linking the volatility or systematic risk of a security to its information environment is the class of parametric estimation risk models. In these models, market participants use available information to estimate the parameters governing the distribution of future returns to individual securities. Barry and Brown [1985], Coles and Lowenstein [1988] and Coles, Lowenstein and Suay [1993] demonstrate that under a diverse set of environments, parameter estimation risk is "priced," since it has real effects on both volatilities and required rates of returns, and is not diversifiable.[4]

Barry and Winkler [1976] show that when the return distribution is stationary (the unknown parameters governing the distribution of returns are time invariant), all past information, regardless of when it was released, is valuable and mitigates parametric uncertainty. With stationarity, uncertainty risk decays as the total, historical stock of information increases. However, if the distribution is non-stationary estimation risk does not decay. Further, the recency of information is

[4]Reinganum and Smith [1983, p. 15] argue that estimation risk "is idiosyncratic rather than systematic, it is diversifiable." Barry and Brown [1985] disagree and show that estimation risk is priced when the informational environment differs across securities. In their model, an increase in the amount of mutual information reduces divergences in opinion, which in turn reduces the required rate of return. Coles and Lowenstein [1988] prove that differential information is not necessary and that the relation between information and covariances holds under the assumption of symmetric uncertainty. Coles, Lowenstein and Suay [1991] demonstrate the robustness of these conclusions when the covariance matrix is known and / or there is asymmetric parametric uncertainty.

crucial. Thus, the magnitude of uncertainty risk depends exclusively on the flow, rather than the stock, of information.

The effects of transaction reporting on measured volatility and systematic risk are clear. Since the introduction of transaction reporting increases the flow of an important category of information, transaction reporting should mitigate parametric uncertainty, reducing both volatility and required rates of return. The cross-sectional empirical implications are threefold. As discussed in Section 3.1, relatively large increases in the flow of information occur when transaction information is (i) more dispersed and (ii) more valuable. Consequently, reductions in both volatility and required rates of return should be greater when (i) transactions information was originally dispersed among more market makers and (ii) each trade contains a higher informational content.

Finally, since the event date examined here represents the first day of transaction reporting, this experiment focuses on a discrete change in the flow of information. Therefore, it is imperative to control for cross-sectional variation in the stock of information. This reasoning underpins the third empirical implication: the reduction in volatility and required rates of return should persist even when variables controlling for the stock of information are included in the specification.

4. Sample Selection

The CRSP-NASDAQ tape identifies all firms that joined the NMS from its inception in April 1982 through December 1987. I manually verified NMS listing dates provided by the CRSP tape and found them to be correct except for those in November 1982 and February 1986. The OTC Daily Record and NASDAQ fact books were used to determine these correct listing dates. The only data availability criterion imposed was that there are at least 80 valid bid and ask quotes for each of two measurement periods: days -100 to -1 and days 0 to +100, where "day 0" refers to the first day of trading on the National Market System. There are 2,639 firms that satisfy this criterion.

Since closing transactions prices are not reported for non-NMS firms, but "best" bid and ask quotes listed on the NASDAQ system at the halt of trading are recorded for both NMS and non-NMS firms, I calculate all returns as:

$$r_t = \ln\left\{\frac{\text{bid-ask midpoint on day } t}{\text{bid-ask midpoint on day } t-1}\right\},$$

where "midpoint" refers to the mean of the closing bid and ask quotes. Using bid-to-bid returns alters none of the conclusions pertaining to variances. Returns have been adjusted for distributions, splits and missing quotes.

5. Average Effects of Transaction Reporting on Volatility

For each firm, two "raw" standard deviations are calculated as: $s = \sqrt{T^{-1}\Sigma(r_t^2 - \bar{r})}$, where T is the number of valid returns in the estimation period. A "pre-NMS" standard deviation is calculated using daily returns from day -100 to day -5, where event day 0 is the first trading day on the NMS; a "post-NMS" standard deviation is calculated from day +5 to +100. The intervening nine days are omitted since they may be contaminated with temporary listing effects (Sanger and McConnell [1986]). Sample means are subtracted since mean returns differ between the two periods. Results are identical when variances are constructed from the sums of squared returns (Skinner [1989] or Merton [1980]). The distributions of pre-NMS and post-NMS standard deviations, as well as differences between or ratios of the two, are highly skewed. Therefore, inferences are based on the difference in the logs of these estimates, as well. The use of logs alleviates skewness, and allows interpretation of the differences as (approximately) percent changes.

Table 2 presents the mean and median of the differences, the percent of changes that are negative and three tests of whether the changes are reliably different from zero. The first test, the common t-test, is valid only when the underlying distribution is normal and the observations are independent. Given the size and approximate symmetry of this sample's distribution, sample means should be drawn from a distribution that is approximately normal.

The percent of variance changes that are negative is also reported. The second test statistic examines whether the proportion of variance declines equals one-half. If changes in variance are cross-sectionally independent, this statistic can be computed as: $t = \frac{(.5-p)}{.5}\sqrt{2639}$.

A third test for changes in volatility, based on the concept of bootstrapping, does not rely on any distributional assumptions (see Efron and Gong [1983] and Efron and Tibshirani [1986]). Rather, a p-value associated with the null is derived solely from an empirical distribution. Since bootstrapping does not make any demands on the underlying distribution, it can be applied to the untransformed, highly skewed data. Consequently, p-values are reported for differences of both the untransformed and log-transformed standard deviations.

Results of the above tests appear in the first two lines of Table 2. It is apparent from the analysis of the change in logs that there is a statistically significant decline of about 8-10% in return standard deviation once the firm is listed on the NMS, regardless of the test performed. The p-values associated with the two t-tests and the bootstraps are all far below the 1% level.

To determine whether these results are specific to the estimation period or eligibility criteria employed, the above analysis is replicated for a variety of samples. Regardless of (i) the estimation period chosen, (ii) the exclusion of those firms with missing values, or (iii) the inclusion of days -4 to +4, test results were consistent with a decline in volatility upon listing[5].

5.1 The Effects of Dependence, Market Volatility, Leverage and Selection Biases:

Since NMS listings are clustered in time, the assumption of cross-sectional independence implicit in the t-statistics discussed above is not valid. Biases of standard errors attributable to cross-sectional correlations are avoided by aggregating cross-sectionally before calculating standard errors (Bernard [1987]). An aggregate time-series is constructed by first calculating a measure of firm volatility for a given day and a given firm. Schwert and Seguin [1990] suggest $\sqrt{\pi/2}\,|r_{jt} - \hat{\mu}_j|$ as an estimate of the standard deviation for a given security j during period t, where $\hat{\mu}_j$ is the sample mean of the series of returns. This estimator is chosen since it provides unbiased estimates of σ_{jt}, if r_{jt} is distributed normal with constant mean.[6] For each firm, a time-series of $\sqrt{\pi/2}\,|r_{jt} - \hat{\mu}_j|$ is calculated for t = -100 to +100. Next, these series are aggregated, yielding a series of cross-sectional average firm standard deviations, S_t, for t = -100 to +100. Note that these numbers reflect the average standard deviation rather than the standard deviation of a portfolio. Thus, firm specific volatility is *not* eliminated through diversification.

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[5]For example, there are 551 firms with no missing data over the period -400 to +400. A comparisons of standard deviations over the period (-400,-1) to (1,400) yields a point estimate of the percent change of -0.321 with an associated t-statistic of -11.65. Further, 74.8% of the changes are negative, yielding a binomial t-statistic of -11.64. Results are similarly strong for comparisons of (-200,-1) versus (1,200), (-300,-1) versus (1,300) and all one hundred day comparisons such as (-400, -301) versus (301, 400). I tried a number of missing value screens, but found that these results were unaffected.

[6]If $x \sim N(\mu,\sigma^2)$ then $E(|x - \mu|) = \sigma^2$. However, since μ is unknown and must be estimated by its sample moment, degrees of freedom are reduced by 1. Note that $\hat{\mu}_j$ is calculated as the overall mean daily return for firm j between days -200 and +200 but excluding days -5 to +5. Since daily returns are not normally distributed, the presence of skewness or kurtosis could impart a bias in estimates of volatility based on mean absolute deviations. I investigated the contribution of changes in higher moments to changes in Schwert-Seguin estimates of volatility. The contribution is negligible, and the point estimates and statistical significance of percent changes in Schwert-Seguin volatilities are similar to those reported in Table 2. Details are available upon request.

To determine the influence of changes in aggregate volatility on this measure (see Black [1976] and Schwert and Seguin [1990]), a time-series similar to S_t is constructed for the market index over the same estimation period for each firm:

$$M_{jt} = |r_{mt} - \hat{\mu}_m| \sqrt{(\pi/2)} \text{ for } t = -100 \text{ to } +100,$$

where r_{mt} is the daily return on the CRSP NYSE-AMEX equal-weighted index.[7] As above, these series are aggregated cross-sectionally.

Figure 2 contains the time-series plots of M_t and S_t. There are two notable features of the S_t series. First, there does not appear to be a trend in the time-series in either the pre-listing or post-listing period. Second, there is an immediate and permanent fall in volatility over the first seven days of NMS listing. This is inconsistent with numerous potential selection bias stories, since it is difficult to conceive of managers or exchange officials choosing to list immediately before a sudden volatility decline. The M_t series does not vary in event time, suggesting that the reduction in volatility upon listing cannot be explained by changes in aggregate market volatility.

Christie [1982] argues that one firm specific determinant of volatility is financial leverage. Holding the volatility of cash flows and the market value of debt constant, an increase in the value of equity decreases leverage and the volatility of equity returns. For the firms considered here, the average increase in the market value of equity over the pre-listing period was 10.7%. To determine whether changes in leverage and market volatility fully explain the reported decline in firm volatility, a cross-sectional regression is estimated, with the log-difference of the standard deviation as the dependent variable. The two independent variables are (i) the log difference of the standard deviation of market returns calculated over the same estimation periods as the independent variable, and (ii) the increase in equity value during the pre-listing period. I am assuming that the market value of debt, which I do not observe, remains unchanged. The intercept of this specification can be interpreted as the estimated percent change in the standard deviation of returns for a firm when the changes in market volatility and leverage are zero.

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[7]The CRSP NYSE-AMEX equal-weighted index was selected to avoid any possible endogeneity problems. For example, if the variance of a security changes once it is listed on the NMS, and the percent of the NASDAQ index comprised of NMS firms increases over time, the variance of the index itself may decline over time. I also employed an index of Blume-Stambaugh [1983] returns to a portfolio comprised of the smallest 5% of all NYSE/AMEX listed stocks, measured by beginning-of-year market value of equity, and a portfolio comprised of the 451 non-NMS firms that were listed on NASDAQ throughout the sample period. Results are unchanged.

Estimation using weighted least squares (WLS) yields:

$$\ln\{\sigma_{j,post} / \sigma_{j,pre}\} = \underset{[-3.56]}{-0.034} + \underset{[9.96]}{0.278} \ln\{\sigma_{mkt,post} / \sigma_{mkt,pre}\} - \underset{[-7.57]}{0.215}\, \Delta Value$$

where $\ln\{\sigma_{j,post} / \sigma_{j,pre}\}$ and $\ln\{\sigma_{mkt,post} / \sigma_{mkt,pre}\}$ are the percent changes from the pre- to the post-NMS period in standard deviations of firm j and the market respectively, and ΔValue is the change in equity value for firm j over the pre-NMS period. The point estimate of the change in volatility is closer to zero than preceding estimates, but is still significantly negative. Though changes in leverage explain some cross-sectional dispersion in volatility changes, the average increase in prices during the pre-listing period is not large enough to explain the shift in volatility.[8]

Though the immediacy of the volatility decline is seemingly inconsistent with a selection-bias story, National Market System listings are not randomly chosen. It is therefore important to determine the effect of the selection process on observed volatility changes. For example, it is possible that firms self-select and join the NMS at a time close to a shift in risk characteristics. Since firm management must apply for voluntary listing, but has no timing discretion in mandatory listing, the effects of self-selection can be approximated by comparing volatility changes for voluntary versus mandatory listings. Consequently, Table 2 also presents test results for the sample of 1,642 firms that satisfy mandatory listing requirements at the time of joining and the 997 that do not. Mean and median changes and the percent of negative changes are virtually identical. The t-statistic associated with the two-sample test of difference in means is 0.19.

Alternatively, a selection bias may stem from the NASD selection process: if the NASD chooses firms with larger volatilities, estimates of volatility changes would be biased downwards, and the point estimates presented above would exaggerate the decline in volatility upon listing. To determine the relation between volatility and selection, I examine the selection of firms for listing on January 22, 1985 using logit analysis.[9] Regardless of the specification employed, coefficients associated with volatility are uniformly significantly negative, suggesting that higher observed volatility reduces the probability of early selection. This result is consistent with the proposition

[8]Numerous additional tests, including the calculation of volatilities from heteroskedastic-consistent return sequences, were performed. The conclusions do not differ. Further, conclusions are robust to the weighting scheme employed. The weights used here are proportional to the fitted values from a Glejser regression with the absolute errors from OLS estimation as the dependent variable. Test statistics calculated with White [1980] heteroskedasticity consistent standard errors are not substantially different.

[9]The NASD had considerable discretion in selecting firms at this time, since this date is the first listing date following the introduction of amended listing requirements. This exercise was repeated with a 1 assigned to those issues listed on the first two or four or eight listing days following the amendment. The exercise was also replicated for the selection process of February 8, 1983. The conclusions remain unchanged.

that the NASD wished to list lower variance, higher "quality" issues. Further, it suggests that any selection bias would reduce the magnitude of reported volatility declines.

6. Average Effects of Transaction Reporting on Bid-Ask Spreads

Since daily spreads are available, I examine the difference and log difference in the percent spread between days -1 and +1. As reported in Table 2, the mean difference and mean log-difference is significantly less than zero when averaged across all firms. Of the 1,097 *raw* spreads that change between these two days, 57.2% of the changes are reductions. This indicates that observed changes in percent spreads are not driven primarily by changes in prices between days -1 and +1.

More powerful tests can be constructed by examining spread data drawn from more than two days. However, this necessitates correcting for other factors that affect spreads. Therefore, averages of the raw bid-ask spread, and averages of share price ($\overline{price}$), shares outstanding ($\overline{shares}$), the number of market makers ($\overline{mkt\ mkrs}$) and market model residual variance ($\hat{\sigma}_\varepsilon$) are calculated. Two observations are generated per firm: (i) sample averages calculated over the 100 days before NMS listing, and (ii) averages calculated over the first 100 days of NMS listing. Employing these averages, a cross-sectional log-log regression is then estimated with the spread as the dependent variable. An indicator variable, NMS, is set to 1 for those observations drawn from the post-NMS period, and 0 for pre-NMS observations. The cross-sectional regression, with 2 x 2,639 observations, yields:

$$\ln(\overline{spread}) = -.390 + \underset{[102.30]}{.367}\ln(\overline{price}) - \underset{[-11.41]}{.407}\ln(\overline{shares}) - \underset{[-87.51]}{.812}\ln(\overline{mkt\ mkrs}) + \underset{[4.17]}{.031}\ln(\hat{s}_e) - \underset{[-4.26]}{.035}NMS$$

These estimates are from a three-step weighted least squares procedure. First, the model is estimated via Ordinary Least Squares (OLS). Next, the unsigned errors from OLS estimation are regressed against the same set of independent variables. The fitted values from this second step are then used as weights when the original equation is estimated via Weighted Least Squares (WLS) in the third step. Test statistics calculated with White [1980] heteroskedasticity consistent standard errors are not substantially different, and conclusions do not change if a linear specification is estimated.

The indicator variable is negative and significant, indicating that the spread is roughly 3.5% lower in the post-NMS period. Auxiliary tests, reported in earlier drafts, indicate that the effect of this reduction in spread on estimated volatilities (see Roll [1984]) is trivial. This finding should not be surprising, given that returns are computed from spread midpoints.

7. Average Effects of Transaction Reporting on Required Rates of Return

To date, there is little evidence supporting the proposition that exchange listing enhances firm value by reducing required rates of return. This lack of evidence refutes the joint hypothesis that (i) exchange listing enhances the information environment (Amihud and Mendelson [1988] and Dhaliwal [1983]) and (ii) required returns are lower for firms with a larger degree of informational availability (Coles and Lowenstein [1988], Clarkson and Thompson [1990] and references contained therein).

Consistent with existing studies, I examine the effect of the introduction of transaction reporting on required rates of return by estimating changes in firm betas.[10] The results in Table 2 indicate that both OLS and Scholes-Williams betas are significantly lower in the post-listing period by about .07 to .09. Assuming that the CAPM is true, and that the risk premium is 8% per year, the change in betas implies a reduction in the cost of equity capital of approximately .5 to .75% per year after listing. Though point estimates of the change are similar across the two measures, Scholes-Williams betas are estimated with less precision, resulting in less power and higher p-values associated with the test statistics. Note however, that the bootstrap p-values are low for both measures.

It is possible that part of the change in betas may be attributable to the increase in prices during the pre-listing period: holding the beta of cash flows constant, a decrease in leverage reduces the equity beta. Regressions were estimated with changes in OLS and Scholes-Williams betas as dependent variables and the change in the market value of equity as the independent variable. The intercepts were significantly negative and similar in magnitude to the point estimates of the change in beta presented in Table 2.

8. Cross Sectional Differences of the Value of Transaction Reporting

In the previous section, declines in variances, spreads and required rates of return were identified for the aggregate sample. In this section, the contribution of transaction reporting in generating these results is evaluated cross-sectionally. The dependent variables chosen are the percent change in spread from day -1 to day +1, the change in OLS betas and the percent changes in volatility between the pre-listing and post-listing periods. I show that the effects of centralized

[10]See Van Horne [1970], Ying, Lewellen, Schlarbaum and Lease [1977], Fabozzi and Hershkoff [1979] and Reints and Vandenberg [1975].

reporting vary with the dispersal of transactions information before listing. Further, reductions in volatility and beta are largest for those issues where the information content per trade is largest. There is also evidence that these effects persist after controlling for the stock of information accumulated at the introduction of transaction reporting.

8.1 Choice of Independent Variables:

Four independent variables are included in the cross-sectional regressions: two that proxy for the existing stock of information, and two that are specifically related to the value of transaction reporting. The functional form of the relation between these variables and changes in spread, required rates of return and volatility, is unknown. Therefore, as in numerous empirical studies of bid-ask spreads, a log-log specification is assumed.

Two commonly employed proxies for the informational environment are size (Atiase [1985]) and age (Barry and Brown [1984] and Clarkson and Thompson [1990]). In this study, the size measure is calculated as the natural log of the market value of equity as of event day -1. Following Clarkson and Thompson, the measure of age or seasoning employed is the natural log of the number of days the firm appears on the CRSP-NASDAQ tape before listing on the NMS. This second measure is downward biased for those few firms that traded on the NASDAQ system prior to the period covered by the tape. These two variables are assumed to be inversely related to the information environment. Consequently, the inclusion of these variables allows for an estimation of the marginal contribution of transaction reporting, after controlling for cross-sectional variation in two commonly employed proxies for the accumulated stock of information.

Including the number of market makers in the regression is especially fruitful, since the sign of the associated slope provides evidence on the nature of information enhancement. Since dealers participating in an issue have strong incentives to collect information on that issue, the number of market makers is positively related to the existing stock of information. Consequently, if the dominant benefit of exchange listing is an increase in visibility, the effect of listing on firms with a large number of market makers should be comparatively small. Conversely, if the benefit of listing is due to the introduction of transactions prices, the opposite effect would be predicted. Without transaction reporting, a larger number of market makers results in individual dealers seeing comparatively fewer transactions. Thus, the introduction of transaction reporting provides comparatively more information in these cases.

As discussed in Section 3, the rapid communication of recent transaction information is more valuable when transactions convey information about the intrinsic value of the stock. This occurs when the proportion of transactions that involve informed traders is large. To proxy for this proportion, I compute the log of the ratio of volatility to volume over the pre-NMS period. A large measure suggests that trades lead to larger revisions in price, and implies a high proportion of informed trading. In these cases, the benefits of transaction reporting would be greater. Using market model residual standard deviations as the numerator, results do not differ from those reported.

The two panels of Table 3 contain summary statistics for the independent variables. Table 3A reports means, medians, quartiles and extreme values for the independent variables before log transformation. Comparisons of means to medians provide an indication of the degree of skewness of these data. Correlations appear in Table 3B. Correlations of the original variables appear in the lower triangle, while correlations between the log-transformed variables appear in the upper triangle. Not surprisingly, there are strong positive correlations between size, age and the number of market makers. A negative correlation between the degree of informed trading and the number of market makers is consistent with the hypothesis that the "depth" of the market for an issue depends on the amount of committed capital, where depth is the volume required to move share prices by one unit (Kyle [1985]).

In all regressions, the return during the pre-NMS period is included as an additional explanatory variable. As discussed in Section 5, this variable alleviates the effect of a change in leverage for the volatility and beta regressions. The change in market volatility, defined in Section 5.1, is also included in the volatility regression to account for shifts due to market-wide factors. A previous version of this study presented specifications accommodating potential regime shifts due to changes in automatic margin eligibility and listing requirement rules. Results presented below are robust to these regulatory changes.

8.2 Results:

Cross-sectional regression estimates appear in Table 4. Again, the three-step procedure outlined in Section 5.1 is used, and reported test statistics are calculated using White [1980] heteroskedastic consistent standard errors.

8.2.1 Changes in Bid-Ask Spread:

There is weak evidence that the change in the bid-ask spread varies with the dispersal of transaction information among market makers: the coefficient associated with the number of market makers as of day -1 is negative, and significant at the 10% level. It is possible that the regression specification with a continuous dependent variable is not applicable here, since spreads (and changes in spreads) are discrete. Potentially, reductions in spread will be observed only when the effects of listing exceed some threshold.

To examine this possibility, I formulate the relation between the change in spread and the number of market makers as a logit model, with the dependent variable equal to one if the spread decreases and zero otherwise. Since almost all changes in the spread were of the smallest possible magnitudes (3/8ths to 1/4th, or 1/32nd to 1/64th, for example), the reduction in information due to the compression of the dependent variable is limited. Regardless of the specification, the coefficient associated with the log of the number of market makers is significant at the .001 level. For example, when only the log of the number of market makers is included, the estimated coefficient is .483 with a χ^2 of 23.47 and an associated p-value of zero. No other variables appear significant. This evidence is consistent with the hypothesis that the benefits of transaction reporting for market makers are largest when transactions information is dispersed.

8.2.2 Changes in Volatility:

Issues with a large number of market makers enjoy larger declines in volatilities. Further, large volatility declines are associated with those issues with relatively higher levels of informed trading. These two estimates are significantly negative, and support the hypothesis that the benefits of transaction reporting depend on the value of transactions information and the dispersal of this information. It is interesting to note that the change in volatility is unrelated to changes in the bid-ask spread. The use of returns calculated from bid-ask midpoints mitigates the effect of the magnitude of the spread on observed volatility (Roll [1984]).

The coefficients associated with the two remaining variables have the predicted sign. The change in volatility is positively related to the change in the volatility of the market portfolio. Further, volatilities are lower for those firms that experienced an increase in the market value of equity and, presumably, a decline in financial leverage, in the pre-listing period.

8.2.3 Changes in Betas:

Reductions in estimated betas appear to be related to the value and dispersal of transaction information. The coefficients associated with both the number of market makers and the informativeness of trading are negative and significant. Further, the magnitudes of the coefficients are economically significant: issues with double the number of market makers or double the informativeness of trades experience incremental reductions in betas of about 0.1.

It is surprising to note that the change in betas is positively related to the increase in the market value of equity over the pre-listing period. Any leverage explanation would predict a negative relation. Indeed, a negative relation is observed between returns and volatilities for the same sample.

Changes in beta are positively correlated with the age of a firm, with the youngest firms showing the largest declines. This result may reflect a relation between age and beta that is independent of NMS listing. For example, if betas decline as a firm ages but the rate of decline slows (Barry and Winkler [1976]), one would expect to see a positive relation between age and the change in beta even if exchange listing were irrelevant.

9. Conclusions

Amihud and Mendelson [1988] suggest that managers can enhance liquidity and lower the cost of raising equity capital in numerous ways, such as exchange listing. Though numerous authors (including Sanger and McConnell [1986]) have speculated on the sources of these benefits, few have explicitly considered the existence of a centralized transaction reporting mechanism as a potential source.

This study documents statistically reliable declines in return volatility, spreads and betas for a sample of firms that joined the National Market System. These benefits occur even though the NMS is not considered an exchange under securities laws, and most aspects of the microstructure, regulatory and information environments are unaltered. Since the primary effect of National Market System listing is the introduction of real-time transaction reporting, these results indicate that the centralization of recent transaction information generates a significant portion of the gains from listing. This intuition is reinforced by findings that reductions in required rates of return, spreads and volatilities are largest for those firms where transaction information was widely dispersed among several market makers and the information content of trading was large.

These results are also useful for predicting which types of firms could benefit most from exchange listing. Grammatikos and Papaioannou [1986] and Ho and Macris [1985] suggest that thinly traded securities with relatively large bid-ask spreads would enjoy the greatest gains. The results presented here indicate that a very different universe of securities would enjoy the most benefits: those firms with a large number of market makers and active information traders.

It is interesting to note that the results of this study provide a counter–example to the widely documented positive correlations between volume, information and volatility. Though differing volume reporting conventions complicate inferences about the effect of NMS listing on trading volume, there is some evidence that volume is typically larger after listing. Further, the introduction of transaction reporting generates an immediate increase in the flow of available information. Existing theories predict that these two factors would increase observed volatility. However, standard deviations fall 3 to 20%, on average, depending on the measure employed. Potentially, increases in floor information enhance the price discovery process and reduce the risks and costs of market-making. This, in turn, results in greater depth, lower volatility and narrower bid-ask spreads.

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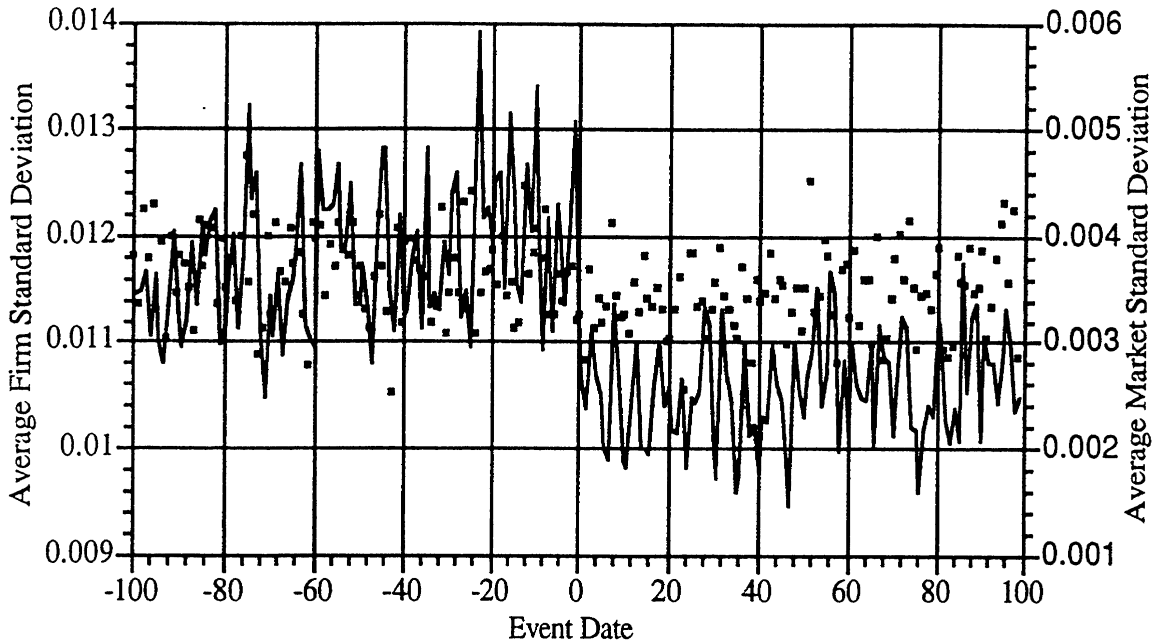
Figure 2
Cross-Sectional Average Firm Standard Deviation and Contemporaneous Cross-Sectional Average Standard Deviation for an Equal-Weighted Portfolio of NYSE-AMEX Stocks



Note: For each firm and each date, an estimate of firm specific volatility is estimated as $\sqrt{\pi/2}\,|r_{jt} - \mu_{jt}|$, where μ_{jt} is the time series mean. A corresponding market volatility is also estimated as $\sqrt{\pi/2}\,|r_{mt} - \mu_{mt}|$. Next, these estimates are cross-sectionally averaged in event time, where event day zero is the first day of trading on the National Market System. This series of market volatilities is plotted with boxes, while the firm volatility sequence is plotted with a solid line.

Table 1
NMS Listing Requirements

	Mandatory Listing	*Voluntary Listing Before 12/84*	*Voluntary Listing After 12/84*		*Continued Listing*
			Option A	**Option B**	
Tangible Assets ($Thousands)	2000	2000	2000	2000	750
Shares Outstanding (Thousands)	500	500	350	800	100
Market Value of Equity ($Millions)	5	5	2	8	na
Minimum Quoted Bid ($)	10	5	3	na	na
Volume (Thousand Shares / Month)	600	600	na	na	na
Market Makers	4	4	2	2	1
Capital and Surplus ($Million)	1	1	1	8	.375
Net Income ($Thousands)	na	na	300	na	na
History (Years)	na	na	na	4	na
Shareholders	300	300	300	300	300

Note: To be eligible for listing on the National Market System, a firm must satisfy either the Mandatory criteria or a Voluntary set. For voluntary listings registered before December 16th, 1984, the firm must meet the one set of voluntary requirements. For those registered after December 16th, 1984, the firm must meet the requirements listed under Option A or those under Option B. Once listed, an issue must satisfy the continued listing requirements, or risk de-listing. Source: the NASD Fact Books, 1982, 1983 and 1984.

Table 2

Summary of Tests for Aggregate Effects of Transaction Reporting

Variable	Sample Mean	t-statistics for $\mu=0$	Sample Median	Percent less than zero	Binomial t-statistic	Bootstrapped p-value
Volatilities:						
$\sigma_{post} - \sigma_{pre}$	-.0014	-5.50	-.0019	59.6	-9.86	0.000
$\ln\{\sigma_{post} / \sigma_{pre}\}$	-.0866	-6.66	-.1079	59.6	-9.86	0.000
Mandatory Listings:						
$\ln\{\sigma_{post} / \sigma_{pre}\}$	-.0886	-5.31	-.1046	59.4	-7.62	0.000
Voluntary Listings:						
$\ln\{\sigma_{post} / \sigma_{pre}\}$	-.0834	-4.02	-.1138	60.1	-6.38	0.000
Spread:						
$Spread_{t+1} - Spread_{t-1}$ (x100)	-.0779	-4.83	0	57.2	-6.30	0.000
$\ln\{Spread_{t+1} / Spread_{t-1}\}$	-.0348	-4.33	0	57.2	-6.30	0.000
Required Rates of Returns:						
$\beta_{post} - \beta_{pre}$	-.0934	-5.31	-.0800	55.6	-5.75	0.000
$\beta_{sw,post} - \beta_{sw,pre}$	-.0745	-3.07	-.0730	53.7	-3.80	0.002

Note: All tests are comparisons of statistics computed over the period +5 to +100 (post) with those computed over the period -100 to -5 (pre). σ is raw variance, β is the estimated slope from the market model and β_{SW} is an estimated Scholes-Williams beta. Spreads are the difference between closing bid and ask quotes deflated by the bid-ask midpoint. The reported statistics are the cross-sectional mean and median, a t-test of whether the sample mean equals zero, the percent of differences which are less than zero, the associated binomial t-statistic and a p-value derived from a bootstrap methodology as outlined in Efron and Tibshirani [1986], with 10,000 replications.

Table 3A

Summary Statistics for Untransformed Independent Variables

	Mean	*Standard Deviation*	*Minimum*	*Quartiles 25%*	*50%*	*75%*	*Maximum*
SIZE Market Value of Equity ($M)	88.0	160.2	0.5	20.2	44.3	96.9	3894.1
NMM1 Market Makers as of Day -1	8.6	4.8	2.0	5.0	7.0	11.0	34.0
AGE Days on NASDAQ	1350.3	1177.7	80.0	272.0	809.0	2675.0	3717.0
INFORM Volatility / Volume in millions	4.61	5.53	0.03	1.47	2.80	5.58	61.0

Table 3B

Correlations of Independent Variables

Untransformed Variables in Lower Left Triangle

Log-Transformed Variables in Upper Right Triangle

	SIZE	NMM1	AGE	INFORM
SIZE Market Value of Equity	1.000	0.356	0.094	-0.533
NMM1 Market Makers as of Day -1	*0.249*	1.000	0.145	-0.603
AGE Days on NASDAQ	*0.142*	*0.088*	1.000	0.145
LogINFORM Volatility / Volume	*-0.204*	*-0.401*	*0.058*	1.000

Note: Data is as of the day before listing on the National Market System. Correlations in the lower left triangle are correlations between the original, untransformed variables. Correlations in the upper-right triangle are correlations between the natural logs of the variables. Market value of equity is the product of the number of outstanding shares and the bid-ask midpoint on the close of the day before listing. The variable AGE will understate the age of those few firms that listed on NASDAQ before the beginning of the CRSP tape. Volume is average daily volume and volatility is the standard deviation of returns, both calculated over days -100 to -5. Source: CRSP-NASDAQ 1987 Tape.

Table 4
Transaction Reporting Effects
Cross-Sectional Regressions

Independent Variable	*Dependent Variable:* $\ln\{Spread_{t+1} / Spread_{t-1}\}$	$\ln\{\sigma_{post} / \sigma_{pre}\}$	$\beta_{post} - \beta_{pre}$
$\ln\{Size\}$	.0055 (0.66) [0.65]	-.0256 (-2.79) [-2.46]	-.0103 (-0.71) [-0.68]
$\ln\{$Days on NASDAQ$\}$	.0164 (-0.45) [-0.46]	.0199 (2.74) [2.59]	.0295 (2.41) [2.41]
$\ln\{$# of Market Makers on Day -1$\}$	-.1441 (-1.68) [-1.85]	-.1956 (-9.19) [-7.82]	-.1147 (-3.82) [-3.66]
$\ln\{$INFORM=volatility / volume$\}$	.0073 (0.69) [0.73]	-.1290 (-10.10) [-8.80]	-.0833 (-4.25) [-4.13]
Average Return: days (-100 to -5)	1.312 (0.53) [0.02]	-15.33 (-6.32) [-5.01]	14.83 (3.08) [2.32]
$\ln\{Spread_{t+1} / Spread_{t-1}\}$		.00006 (0.00) [0.00]	
$\ln\{\sigma_{mkt,post} / \sigma_{mkt,pre}\}$		.2734 (10.75) [9.67]	

Note: Regressions are based on 2,523 observations. Statistics are computed over the period +5 to +100 (post) and over the period -100 to -5 (pre). Spread is the actual bid-ask spread, σ is raw standard deviation, Ret is the mean daily return, σ is the standard deviation of a time series of returns divided by expected market volatility, σ_{mkt} is the standard deviation to the equally weighted CRSP-NYSE/AMEX (without dividend) index and β is the OLS beta. Regressions are estimated in three steps: (i) OLS is estimated, (ii) a Glejser is run with the absolute errors from OLS as the dependent variable and the same independent variables, and (iii) WLS is estimated with the fitted values from the Glejser as weights. T-statistics in parentheses ( ) are generated from the WLS procedure, while t-statistics in brackets [ ] use White [1980] heteroskedastic consistent standard errors.