Why Has Trading Volume Increased?

by

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Share turnover has increased dramatically over the past few years. We explore patterns in trading activity accompanying this increase and analyze possible causes. Higher turnover is associated with more frequent smaller orders, which have progressively formed a larger fraction of trading volume over time. Turnover has increased the most for stocks with the greatest level of institutional holdings. Tick size decreases and increases in the volatility of equity fund flows appear to have played roles in this increase. Variance ratio tests indicate that the increase in turnover has been accompanied by greater production of private information, possibility stimulated by lower trading costs. The sensitivity of turnover to past returns has increased in recent years, perhaps revealing a more widespread use of quantitative trading strategies.

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Abstract

Share turnover has increased dramatically over the past few years. We explore patterns in trading activity accompanying this increase and analyze possible causes. Higher turnover is associated with more frequent smaller orders, which have progressively formed a larger fraction of trading volume over time. Turnover has increased the most for stocks with the greatest level of institutional holdings. Tick size decreases and increases in the volatility of equity fund flows appear to have played roles in this increase. Variance ratio tests indicate that the increase in turnover has been accompanied by greater production of private information, possibility stimulated by lower trading costs. The sensitivity of turnover to past returns has increased in recent years, perhaps revealing a more widespread use of quantitative trading strategies.

I. Introduction

The literature on financial markets has traditionally focused on explaining asset prices, while trading activity has attracted only peripheral attention. Indeed, Rubinstein (1975), Hakannsson, Kunkel and Ohlsen (1982), and Milgrom and Stokey (1982) suggest that there will no trading in a market consisting of rational agents with identical priors. Empirical investigations of well-known asset pricing models such as the CAPM have also centered only on the determinants of expected returns. Yet trading activity is an inalienable feature of financial markets and, thus, warrants separate examination. Indeed, trading volumes are large in financial markets. For example, the NYSE website indicates that the annual share turnover rate in 2003 on the NYSE was about 99%, amounting to a total volume of about 350 billion shares. Assuming a per share value of $20 and a 50 basis point round-trip cost of transacting, this amounts to a transaction cost of several billion dollars that the investing public paid in 2003. In his AFA presidential address French (2008) suggests that the cost of price discovery via trading was about $99 billion in 2006.[1]

In this paper, rather than explaining the high levels of trading volume, we focus on the fact that trading activity has increased rather dramatically over the past few years. For instance, the value-weighted average monthly share turnover (on the NYSE) increased from about 5% to about 12% from 1993 to 2005. We search for possible causes of this strong trend. Although examining an unusual pattern in trading is a worthwhile pursuit in itself, our study attains further significance because recent research has found that trading activity is related to the cross-section of expected returns and hence to the cost of equity capital.[2] Thus, an increased level of trading activity should be associated with a decreased cost of capital, *ceteris paribus*.

[1]The cost of price discovery in French (2008) includes trading commissions as well as the fees charged by mutual funds and hedge funds. French documents that U.S. investors spent an average of 0.67% of the aggregate value of the market each year over the period 1980-2006 in searching for superior returns.
[2]See Brennan, Chordia and Subrahmanyam (1998) and Chordia, Subrahmanyam, and Anshuman (2001).

Previous time-series studies of volume have largely focused on the contemporaneous links between volume and other variables such as return volatility or short-term patterns in volume. For example, a number of other empirical studies have documented a positive correlation between volume and absolute price changes (see Karpoff, 1987, Schwert, 1989, and Gallant, Rossi, and Tauchen, 1992). Amihud and Mendelson (1987, 1991) find that volume is higher at the market's open. Foster and Viswanathan (1993b) demonstrate a U-shaped intraday volume pattern and also find that trading volume is lower on Mondays. Gallant, Rossi, and Tauchen (1992) investigate the relation between price and volume using a semi-nonparametric method. In their time-series analysis, they find that daily trading volume is positively related to the magnitude of daily price changes and that high volume follows large price changes.

In other work, Lakonishok and Maberly (1990) observe that volume from individuals is larger but institutional volume is smaller on Mondays. Ziebart (1990) documents a positive relation between volume and the absolute change in the mean forecast of analysts. Campbell, Grossman, and Wang (1993) and Llorente, Michaely, Saar, and Wang (2002) analyze the dynamic relation between volume and returns in the cross-section.

There also is an extensive body of theoretical research on trading volume. First, as suggested by models of dynamic asset allocation such as Merton (1971), it is intuitive that trading could arise naturally from the portfolio rebalancing needs of investors in response to changes in expected returns. Thus, Lo and Wang (2000) examine the implications of portfolio theory for the cross-sectional behavior of trading volume.

Apart from the portfolio-rebalancing motive, there are two schools of thought that develop theories for trading activity. In the first, which is founded on the rational expectations paradigm, trading is precipitated by both non-informational reasons and by the profit-seeking motives of privately informed investors. Such models generally

examine trading among privately informed traders, uninformed traders, and liquidity or noise traders.[3] Investors try to infer information from trading activity and market prices. Noise trading usually hinders this inference.

As per the second school of thought trading is induced by differences of opinion. This line of research often de-emphasizes the role of information gleaned from market prices, and does not include noise traders.[4] In Harris and Raviv (1993) and Kandel and Pearson (1995), investors share the same public information but interpret it differently, a scenario which results in trading activity. Testing this line of thinking, Chordia, Huh, and Subrahmanyam (2007) study the cross-section of trading activity and show that dispersion of analyst opinion is positively related to trading volume. They also show that volume is strongly related to past returns in the cross-section.

We go beyond earlier work on the cross-sectional and time-series determinants of volume *levels* by focusing on four main questions related to recent *trends* in trading activity: (i) What microstructure patterns have accompanied the sharp increase in turnover? Is the increase due to changes in transaction frequency, or trade size, or both? (ii) What can the data tell us about whether institutions or individuals are primarily responsible for the turnover trend? (iii) Is it possible to discern why trading by certain trader classes has increased? Does the increase correspond to regulatory changes such as tick size decreases or trends in other determinants of turnover known from earlier literature? (iv) What have been the consequences of the shift in trading activity? For example, has production of private information increased? Have there been changes in the cross-section of expected turnover due to the actions of hedge funds that exploit cross-sectional return predictability documented by academic researchers?

[3] See Grossman and Stiglitz (1976, 1980), Hellwig (1980), Kyle (1985), Admati and Pfleiderer (1988), Grundy and McNichols (1989), Foster and Viswanathan (1990, 1993), Kim and Verrecchia (1991a, 1991b), and Wang (1994).

[4] Examples of this literature include Harrison and Kreps (1978), Varian (1985, 1989), Harris and Raviv (1993), and Kandel and Pearson (1995).

We analyze the preceding issues in several stages. First, we establish some basic facts about turnover. In particular, we show that volume has increased substantially for both index and non-index stocks, suggesting that indexation alone is not responsible for increase in trading activity.[5] We also document that the turnover increase has principally resulted from smaller orders and greater frequency of transactions.

We then ask whether institutions or individuals are primarily responsible for the increase in turnover. Stocks with more institutional holdings experienced the greatest increases in turnover, indicating a prominent causative role for institutions. In addition, changes in the breadth of ownership (as measured by the number of shareholders) are not associated with changes in turnover in the cross-section. Assuming that changes in ownership breadth primarily reflect changes in dispersed retail ownership (as opposed to concentrated institutional ownership), this further points to the role of institutions in causing turnover trends.

The natural question that arises next is why institutions appear to be trading more frequently in recent years. While secular decreases in trading costs due to technological advances and tick size drops are well-known and have undoubtedly influenced trading activity,[6] have other known determinants changed in a manner consistent with increases in institutional trading? We consider this question by looking at the role of shifts in analyst forecast dispersion, equity fund flows, and option-implied volatility. The central finding that emerges is that fund flows have become more volatile in recent years. This change can be attributed to an increase in individuals' frequency of asset allocation owing to technological innovations such as online access, which, in turn stimulates

[5] French (2008) shows that the fraction of US domestic equity invested passively has increased steadily for all four groups of institutions (defined benefit plans, defined contribution plans, non-profits and public funds) examined. For instance, non-profits start with 2.8% of their assets being passively managed in 1986 to 28.7% in 2006.

[6] As Chakravarty, Panchagesan and Wood (2005) point out, the decline in trading commissions can be attributed to the growth of alternative, automated trading systems as well as online brokerage firms which allow institutions a greater choice of execution venues and consequently, greater competition between providers of trading services.

trading activity by their agent institutions. The evidence indicates that the role of the other turnover determinants in causing turnover shifts is likely limited. Overall, the results suggest that the significant increase in institutional turnover has primarily been stimulated by shifts in fund flow volatility as well as decreases in trading costs.

Finally, we turn to the effects of increased trading by institutions on their own account, perhaps induced by decreases in commissions. One possibility is that institutions are able to trade more effectively on private information in recent years. A second possibility is that they are able to exploit findings on cross-sectional return predictability more effectively. Evidence supports both of these conjectures. First, our analysis of open/close and close/open variance ratios (along the lines of French and Roll, 1986) indicates that increased turnover has indeed been accompanied by greater production of private information. Second, the increased information production is most pronounced for stocks with the highest levels of institutional holdings. Third, turnover has become more sensitive in recent years to return predictors that are increasingly employed in quantitative trading strategies used by hedge funds, pointing to the prominent role of these institutions in causing turnover patterns.

The remainder of this paper is organized as follows. Section II describes the data. Section III presents some preliminary evidence documenting the increase in trading activity. Section IV analyzes causes for increases in turnover and establishes that the increase in turnover is likely due to increased institutional trading. Section V analyzes causes and consequences of greater institutional trading, while Section VI concludes.

II. The Data

The sample period 1993 to 2005 was chosen because TAQ data are available beginning in 1993. For the most part (an exception is pointed out later), we use NYSE-listed stocks

to avoid aggregating volume across exchanges with different trading protocols. This also allows us to manage the extraction of the voluminous transactions data.

Stocks are included or excluded during a calendar year depending on the following criteria:

- To be included, a stock had to be present at the beginning and at the end of the year in both the CRSP and the intraday databases.
- If a firm changed exchanges from Nasdaq to NYSE during a year (no firms switched from the NYSE to the Nasdaq during the sample period), it was excluded from the sample for that year.
- Because their trading characteristics might differ from ordinary equities, assets in the following categories were also expunged: certificates, ADRs, shares of beneficial interest, units, companies incorporated outside the U.S., Americus Trust components, closed-end funds, preferred stocks and REITs.
- To avoid the influence of unduly high-priced stocks, if the price at any month-end during the year was greater than $999, the stock was deleted from the sample for the year.

Given that a stock is included in the sample, its transaction data are filtered and the trades are signed as in Chordia, Roll and Subrahmanyam (2008). Note that due to the filtering of the transactions data, a number of trades, (especially for large stocks with a large number of trades), are excluded because of out of sequence recording of trades or because the trades are recorded before the open or after the close. Due to this exclusion of trades, the turnover obtained using transactions data from TAQ is understated as compared to turnover obtained from CRSP. All aggregates are value-weighted using market capitalization at the end of the previous calendar year. Two subperiods are selected to give an indication of changing conditions. They span seven and six complete calendar years, respectively; Subperiod 1 includes 1993 to 1999 and Subperiod 2 covers

2000-2005. We also obtain data on determinants of turnover from various sources, which are described in a later section.

III. Preliminary Evidence

Figure 1 presents the value-weighted monthly turnover for NYSE stocks from 1993 through 2005 inclusive. We first compute the monthly turnover for each stock using trading volume and the number of shares outstanding from CRSP. Then we calculated the value-weighted turnover each month. To examine the possible role of indexation, Figure 1 has separate plots for S&P500 and non-S&P500 NYSE stocks.[7] This is also a rough categorization for large and small cap stocks since stocks included in the S&P500 are generally the larger firms. As can be seen, turnover has gone up for both groups of stocks. The increase is quite large, from below 6% (per month) at the beginning of the period to 10-12% towards the end. Table 1 presents summary statistics associated with turnover for the two subperiods.

There is no evidence that turnover of index (large cap) stocks increased more than that for non-index (smaller cap) stocks — an unreported test shows that the average difference in turnover between non-index and index stocks throughout the period is positive and marginally significant.[8]

The dramatic increase in dollar turnover could result from an increase in trading frequency or in the average trade size, or possibly both. To shed some light on this issue, Panel A of Figure 2 plots the daily value-weighted average dollar trade size per transaction.[9] The daily dollar trade size for each stock is computed as a ratio of the

[7] The S&P 500 index is by far the most common benchmark for index funds (see, for example, Fabozzi and Molay, 2000).
[8] Frequently in the paper, we omit the details of difference in means tests, because we simply use the standard t-statistic for this purpose (see, for example, http://www.socialresearchmethods.net/kb/stat_t.php).
[9] Figures 2 through 5 (and Tables 2 through 7) use daily aggregate data derived from intraday transactions in the TAQ database; all other tables use monthly data obtained from CRSP.

dollars traded each day to the total number of daily transactions. The value-weighted average dollar trade size per transaction has declined precipitously over the past few years, from about $100,000 to about $30,000. Thus, trades are now being conducted in ever-smaller units during recent years. A regression with a linear trend term confirms the drop in trade size, since the coefficient of the trend is significant with a t-statistic of –51.

The value-weighted average number of transactions per day is plotted in Panel B of Figure 2. It has increased dramatically through the sample period. Again, a linear trend regression confirms the statistical significance of this increase. Table 2 provides summary statistics on the average trade size and number of transactions by subperiod. It indicates that the average trade size decreased by about 60%, whereas the average number of transactions increased four-fold across the two subperiods. Consequently, the increase in total dollar turnover is entirely driven by an increase in trading frequency, which has more than offset the decline in average trade size.

As an additional piece of evidence regarding the source of the increase in dollar turnover, Figure 3 documents the proportion of dollar volume in trades of less than or more than $10,000. For each stock each day, we use the transactions data to simply add up the dollar trading volume that is less than and greater than $10,000. As usual, the value-weighted averages are computed using the end of previous year's market capitalization. There is a clear pattern: the proportion of volume due to smaller (larger) orders has been steadily growing (falling). Again, trend regressions confirm this finding, in that the coefficients of the trend are strongly positive (negative) and significant for the proportion of volume due to small (large) orders. Further, Table 3 provides magnitudes across the two subperiods and indicates that the proportion of small trades almost doubled in the second period relative to the first.

The next section considers the preceding findings in more depth by addressing the role of liquidity and the relative importance of retail and institutional investors in turnover trends.

IV. Further Analysis of the Turnover Increase

The previous section suggests that the increase in turnover is due to ever-smaller trades conducted ever more frequently. There are three possible reasons for this (which are not mutually exclusive). First, liquidity, as measured, for example, by effective spreads, may have shown a greater decline for smaller orders relative to larger ones due to exogenous shifts in ease of trading for small orders (e.g., by way of the NYSE Direct system).[10] Second, retail investing, consisting predominantly of smaller trades, may have increased due to the advent of online trading technologies (Barber and Odean, 2002). Third, institutions may have resorted to splitting orders to take advantage of lower per-trade commissions and reduced depths documented in Chakravarty, Panchapagesan and Wood (2005) as well as Jones and Lipson (2001).

A. The Role of Liquidity

Do turnover trends mirror a pattern in liquidity? In Figure 4, Panel A, we document the average effective spreads for large orders (>$10,000) and small orders (≤$10,000) over time.[11] Spreads have been decreasing for both large and small orders. Indeed, Panel A of Table 4 indicates that the average effective spread is about seven cents lower in 2000-2005 than in 1993-1999 for each type of order, and an unreported test indicates that the difference is statistically significant at the 1% level in both cases. This indicates a secular increase in liquidity for reasons unrelated to the mix of orders. Panel B of Figure 4 as

[10] The NYSE Direct system is a procedure introduced in 2000 for automated execution of small orders (less than 1,099 shares). See, for example, Huang (2002).

[11] The effective spreads are calculated by taking twice the absolute difference between the transaction price and the mid-point of the prevailing bid-ask quote for each matched transaction. These are then averaged during the trading day; then value-weighted to obtain an aggregate.

well as Table 4 documents depths at the inside quote for the two subperiods. Consistent with Chordia, Roll, and Subrahmanyam (2001), inside depths have decreased in the second subperiod. The decrease in depths can be attributed to decreases in the minimum tick size, which has reduced the willingness of market makers to display large quote sizes at the inside price quotes.[12] However, tick size shifts are associated with dramatically reduced bid-ask spreads (Chordia, Roll, and Subrahmanyam, 2001).

To examine the impact of trading costs on turnover, we exploit the exogenous natural experiment where the tick size was reduced from an eighth to a sixteenth on June 24, 1997 and from a sixteenth to decimals on January 29, 2001. We run cross-sectional regressions of changes in average turnover between one month prior and one month after the change in the tick size as a function of the change in the average relative quoted spread (quoted spread divided by the quote midpoint)[13] and the change in daily volatility across the same period. Inclusion of volatility as a control variable is suggested by evidence in Karpoff (1987) and Chordia, Huh, and Subrahmanyam (2007) that volatility is a important driver of volume.

Results from the regression appear in Table 5. The table shows that the coefficient on spreads is negative and significant around both tick size decreases even after accounting for the effect of the control variable. This indicates that the decrease in tick size is related to the increase in turnover. The results suggest that a decline in trading costs has led to an increase in trading. It is not surprising to find that a decline in the cost of a product could lead to an increase in its consumption.

B. Retail vs. Institutional Trading

[12] This does not necessarily mean that overall depth has decreased, because depth outside the minimum quotes may well have increased. The data on overall depth are available only in the limit order book.
[13] We have also checked that the results are essentially unchanged when the relative effective spread is used.

Another possible causative influence on the turnover trend is that retail investors are participating to a greater extent because of enhanced access to online trading (Barber and Odean, 2000). A further possibility is that institutions are able to trade more frequently and more cheaply. To provide some perspective on these possibilities, we sort all stocks into five groups by the institutional holdings, measured by the percentage of shares held by institutions in the immediately preceding quarter. The average turnover for these groups is plotted in Figure 5. Group 5 has the highest institutional holdings and group 1 the lowest. As shown in the figure, turnover has increased the most for stocks that are held most by institutions, and there is a monotonic relation in the turnover trends across the groups. This suggests that retail investing alone probably does not account for the increased turnover. Indeed, the data used for Panel A of Table 6 indicate that the average difference in turnover across lowest and highest institutional holdings groups is about 3.6% over the period 1993-1999 and approximately 6.0% over the period 2000-2005. An unreported test indicates that the difference in these numbers is statistically significant with a p-value less than 1%.[14]

Further evidence on the role of institutions in the turnover increase appears in Panels B and C of Table 6, which provide turnover due to large and small orders separately for the two subperiods across the institutional holdings quintiles. It can be seen that for the group with the largest institutional holdings, small order turnover has increased by about 400% across the two sub-periods, whereas the corresponding increase is only about 120% for the lowest holdings group. The corresponding numbers for large order turnover are 30% and 21%, respectively.

In additional analysis, we consider the average ratios of turnover across the extreme institutional holdings quintiles. For small orders, we find that the ratios of turnover in the largest quintile to that in the smallest one are respectively 0.71 and 1.51 for the first and second subperiods. The corresponding numbers for large order turnover

[14] The difference in turnover between highest and lowest institutional ownership groups regressed on a trend line has a t-statistic of 15.8 and an adjusted r-square of 62%.

are 2.40 and 2.67. An unreported test shows that the ratio is statistically greater (at the 5% level) in the second subperiod for both small and large orders, pointing to more institutional trading in recent years. Moreover, the average difference in the ratio (for large orders relative to small orders) is 1.69 in the first period but 1.15 in the second, and the first number is statistically greater than the second at the 1% level. This indicates that the proclivity of institutions to submit small orders relative to large ones has increased in recent years.

It is possible that institutional holdings are proxying for firm size, thus contaminating our inferences. To address this, we independently sort firms into institutional holdings and market capitalization-based quintiles and document total turnover, and turnover for large and small orders in Table 7. The general pattern is preserved even within size quintiles. Specifically, turnover generally is higher for the firms with greater institutional holdings, holding constant the size quintile. It is also easily verified that in 14 out 15 cases (five each for total, small order, and large order turnover), the ratio of average turnover in the second sub-period to that in the first is greater for the quintile representing the largest level of institutional holdings than for that with the lowest holdings. The difference in total turnover across quintiles with the largest and smallest holdings is statistically greater (at the 1% level) in the second sub-period within every size quintile. It also is readily discerned that the difference in these ratios across small and large holding quintiles is particularly pronounced for the large order turnover. Specifically, the difference in the average turnover ratio across the two institutional holding quintiles is over two in almost every size group for the large order turnover, but the mean difference across the size quintiles for small order turnover is only 0.03. In fact, over the period 1993-1999 the small order turnover decreases with institutional holdings. Overall, this again supports the notion that the increase in turnover is driven more by institutions rather than retail investors.

There is an important caveat to the above analysis. While we make claims about the increase in trading by institutions, it should be noted that all we have is data on institutional holdings of stocks. We do not have data on trading by institutions. Also, we are not claiming that trading by retail investors has decreased over time. What we are claiming is that trading by institutions or rather trading in stocks with higher institutional holdings has increased by more. Therefore, we present additional pieces of evidence to support the link between turnover increases and increased institutional trading.

First, as another indicator to distinguish retail from institutional trading, we examine changes in the number of shareholders over time.[15] Changes in the number of shareholders may be attributed to changes in the breadth of ownership and may be linked to changes in the number of retail investors holding, and thus trading, stocks. We obtain the number of shareholders from Compustat and calculate the value-weighted number of shareholders each year. This quantity shows a modest increase during the sample period; thus, the average annual numbers of shareholders are 181,896 and 210,772 in the 1993-1999 and 2000-2005 periods, respectively.

Further light on the number of shareholders is shed by the following exercise. For each stock listed in both the former and latter subperiods, we calculate the change in its average turnover across the periods and the change in the number of shareholders. The change in average turnover is then regressed on the change in shareholders. The coefficient in this regression is insignificant with a t-value of –0.29, indicating that changes in the shareholder base have not had a significant impact on turnover, again pointing to institutional trading, rather than changes in breadth of ownership as the stronger determinant of turnover.

[15] It would be desirable to have direct data on retail trading. However, these data are not available for our sample period, because the standard discount brokerage dataset used, for example, by Odean (1998) and Barber and Odean (2000) does not extend beyond the year 2000.

We next consider serial correlation in order imbalances as a way to distinguish trends in retail and institutional trading. First order serial correlation in order imbalances are strongly positive (Chordia, Roll, and Subrahmanyam, 2002). Lee et al. (2005) attribute these serial correlations to both reputational herding (Scharfstein and Stein, 1990) as well as order splitting (Kyle, 1985) by investors. An overall increase in the serial correlation of order imbalance in more recent years would be consistent with the increase in turnover and would signify either increased herding or increased frequency of split orders. While a change in the serial correlation of small orders can be attributed to retail investors as well as institutional investors, an increase in the serial correlation of large orders is more likely to be driven by institutional trades. Motivated by these arguments, in Table 8, we present the daily share order imbalance serial correlations for the two subperiods,[16] and across the five institutional holdings quintiles (the correlations are calculated stock by stock, then averaged across stocks). We find that the overall serial correlation increased in the second subperiod for the full sample as well as for every all holdings quintile. In addition, we find that the serial correlations for small orders decreased moderately but that for large orders increased substantially in the second subperiod. Further, the point estimate of the increase is greatest for the largest holdings quintile.[17] That the increase in serial correlation in large orders (which are more likely to be used by institutions) mimicks the overall imbalance autocorrelation again supports the notion that increased turnover by institutions drives the overall trend in turnover.

Overall, the evidence suggests that increased trading by institutions in recent years has influenced the trend in total turnover. We next turn to causes for increased institutional trading.

V. Causes of Greater Institutional Trading

[16] The order imbalances are calculated using the Lee and Ready (1991) method (see Chordia, Roll, and Subrahmanyam, 2002).

[17] Of all the changes in serial correlations in the second subperiod relative to the first, only the increases listed in the second columns of Panels A and C (i.e., those for the overall sample, representing the combined and large order imbalance) are significant at the 10% level. All other changes are insignificant.

The previous section pointed to evidence suggesting that institutional trading, as opposed to retail investing, appears to be more responsible for the dramatic increase in turnover in recent year. This section examines why institutional trading may have increased in recent years, and also considers the potential influence of such an increase on price formation and the cross-section of expected turnover.

A. Changes in Potential Determinants of Trading Activity

Three important determinants of trading activity are dispersion in analysts' forecasts, return volatility, and equity fund flows. Have they changed in recent years in a manner consistent with the dramatic increases in turnover?[18] The answer to this question depends on three empirical constructs: (1) the monthly forecast dispersion, defined as the standard deviation of earnings per share (EPS) forecasts from multiple (two or more) analysts,[19]; (b) the value-weighted average dispersion index for the aggregate market, where the weights are based on market capitalization as of the end of the previous year; (c) the VIX, a measure of the implied volatility[20] of the S&P 500 index published by the Chicago Board Options Exchange, (available from the Option Metrics database.)

The average values of the dispersion index and VIX across the two subperiods are presented in Panels A and B of Table 9. The proportional differences in means for these two potential determinants of turnover are small relative to the corresponding turnover statistics documented in Table 1. Statistically, an unreported test indicates that the difference in dispersion is not significant, whereas that in VIX is marginally significant (t=-2.19). However, the changes in either variable do not appear large enough to justify

[18] See Chordia, Huh, and Subrahmanyam (2007) for documentation of the importance of these determinants in the cross-section of turnover.
[19]Obtained from the I/B/E/S database disseminated by the firm Thomson Financial. Stocks without multiple forecasts are not included in the sample.
[20] We use implied option volatility because the speculative activity that sparks turnover would likely respond to expected volatility, rather than realized volatility.

the dramatic increase in turnover in recent years. It can thus be asserted that the increase in turnover is likely not due to increased dispersion of analyst opinion or greater implied volatility of the stock market.

While the previous section suggests that institutions and not individual investors may be the driving force influencing turnover, individual investor behavior may have changed over time in a way that may have influenced institutional turnover. Thus, for example, the technology to switch between asset classes has improved substantially in that it now just takes a few clicks of the mouse to switch into a new mix of assets.[21] Based on either valid or invalid indicators, individuals likely may be prone to changing asset mixes more frequently in recent years. This implies that the volatility of fund flows into equity markets may have increased in recent years, which may, in turn, have influenced turnover.

To shed some light this conjecture, we obtain aggregate weekly flows to equity mutual funds from 1993 to 2005 from AMG Data Services. We present summary statistics for these flows across the two subperiods in Panel C of Table 9. Mean fund flows actually decreased in the later subperiod and the change is marginally significant. The decrease in the mean level may be due to the aftermath of the tech stock bubble. However, the volatility of fund flows did increase, as conjectured. Indeed, an F-test indicates that the change in fund flow volatility is statistically significant at the 5% level.[22] This is consistent with the notion that the frequency of asset allocation has increased in recent years. While it is difficult to link this change conclusively to the increase in turnover, we calculate the correlations between detrended absolute changes in fund flows and, in turn, detrended S&P500 and non-S&P500 turnover. These correlations are 0.107 and 0.133, respectively. Though the correlations are modest, they do suggest a link between increased volatility of fund flows and increased turnover.

[21] See, for example, Brunnermeier and Nagel (2006).

[22] To address the issue that potential non-stationarities could influence the volatility estimates, we also tested for equality of variances of the linearly detrended data for mutual fund flows. The volatility estimates and conclusions of statistical test are virtually unchanged using the transformed fund flow data.

B. Production of Private Information

As the previous section indicates, one potential reason for increased institutional trading is simply due to increased frequency of asset allocation by individuals through their institutional agents. However, institutions may also be trading more frequently on their own account due to exogenous factors such as lower tick sizes (viz. Table 4), decreased commissions (French, 2008), and improvements in trading technology (Chakravarty, Panchapagesan, and Wood, 2005). Such trading may enable them to exploit private information more effectively because decreased trading costs may increase returns from information-based trading (Admati and Pfleiderer, 1988). On the other hand, if institutions are only passing along individual investors' asset allocational decisions to the financial markets then one would not expect much change in the flow of private information to the market. Open/close versus close/open variance ratios can shed some light on these competing hypotheses. French and Roll (1986), and, more recently, Chordia, Roll, and Subrahmanyam (2008) argue that these ratios reveal the degree of private information produced by the trading process. A graph of these variance ratios for each sample month, together with a plot of the six-month moving average, appears in Figure 6.

There is no dramatic or vivid trend in the variance ratios. However, a statistical test reveals a significant difference in the average ratios across the 1993-1999 and 2000-2005 periods. As Panel A of Table 10 reports, the variance ratios in the former and latter periods are 9.58, and 13.09, respectively. Thus, the variance ratio increased by about 37% in the second subperiod, and it is easy to verify that this change is statistically significant at the 5% level. Thus, there is evidence that increased turnover, possibly due to lower trading commissions, has been accompanied by increased trading on private information.

We have earlier argued that the evidence supports the notion that the increase in trading activity in recent years is driven primarily by institutions. If this is the case, and variance ratios capture production of private information by institutions, then we would expect a greater shift in the variance ratios in stocks more widely held by institutions. We thus examine variance ratio shifts for stocks divided into groups by institutional holdings. Results appear in Panel B of Table 10. It can be seen from the table that the increase in the variance ratios is most pronounced for stocks with the highest levels of institutional holdings. Indeed, the percentage changes in the variance ratios in the second subperiod relative to the first are –5.9%, 7.8%, 45.7%, 83.7%, and 61.1% for the smallest to the largest holdings groups, respectively, and only the latter three increases are statistically significant at the 5% level. Thus, the increase in variance ratios is most evident in stocks with the highest levels of institutional holdings. The evidence therefore supports the dual notions that institutions are trading more actively and exploiting private information more effectively in recent years.

C. The Impact of Hedge Funds: Changes in the Cross-Section of Expected Turnover

A potential reason for increased institutional trading activity has to do with the proliferation of hedge funds, possibly stimulated by exogenous decreases in trading costs described in the previous subsection. Academic research may also have stimulated hedge fund growth. Specifically, in the early 1990s academics (e.g., Fama and French, 1992, Jegadeesh and Titman, 1993) came up with reliable predictors of returns in the cross-section that did not appear to be related to risk. Fung and Hsieh (2000) suggest that these effects form the backbone of trading strategies used by many hedge funds. Thus, a possible explanation for the increased turnover is that institutions as a group, possibly hedge funds, have employed rapid trading strategies more vigorously, as a result of prior academic research as well as secular declines in trading costs.

This hedge fund explanation would be bolstered if turnover has become more sensitive to typical quantitative strategy triggers. We cross-sectionally regress turnover for all NYSE-listed stocks on two explanatory variables. The first is the absolute value of the one-month lagged return, which approximates changes in book/market or short-term momentum. The second explanatory variable, intended to capture changes in long-term momentum, is the absolute value of the compounded return from month t-2 to month t-6, where t is the month in which turnover is measured.

Figure 7 plots the cross-sectional regression coefficients of monthly turnover on the two absolute return variables. The figure shows that turnover has become more sensitive to the one-month lagged return in recent years. Table 11 provides summary statistics for the coefficients across the two subperiods. The mean coefficients for both return variables are greater in 2000-2005 than in 1993-1999, and the difference is statistically significant at the 1% level for the one-month lagged return, but not significant for the longer-term return.

As a robustness check, we also perform panel regressions that adjust for heteroskedasticity and autocorrelation using the approach of Kmenta (1986).[23] The dependent variable is turnover, and the explanatory variables are the same as those in Table 11. Also, these explanatory variables are interacted with an indicator variable that is unity in the 2000 to 2005 period, and zero otherwise. The procedure requires a balanced panel, so the sample uses the 724 NYSE-listed firms that were present in every month of our sample period.

Coefficients of the four variables (the untransformed ones and their interactions with the 2000-2005 dummy) appear in Table 12. As can be seen, turnover is strongly and positively related to the past return variables. Consistent with the Table 11 coefficients,

[23] The estimation is carried out using the statistical package Shazam. The model used allows for cross-sectional heterogeneity in residual variance as well as first-order autoregressive error terms for each cross-sectional unit. Details are available in SHAZAM (1993, pp. 245-252)

the interacted variables are both positive and significant, confirming that turnover has indeed become more sensitive to past absolute returns in the later years of the sample.

The preceding evidence indicates that at least part of the increased turnover may be due to the increased reliance on book/market and momentum-based strategies. However, the evidence is only suggestive. As an additional piece of evidence that aggregate turnover is influenced by cross-sectional sensitivities of turnover to lagged returns, we present a vector autoregression of turnover and the two cross-sectional return coefficients whose behavior is depicted in Figure 7. The idea is that increased turnover can imply increased shifts in book/market or momentum due to the activity of unsophisticated investors. This can, in turn, increase the sensitivity of turnover to lagged returns as institutions seek to address perceived deviations of prices from fair values. However, increased sensitivity of turnover to lagged returns might mean increased arbitrage activity to exploit mispricing, which may imply increased aggregate turnover both contemporaneously and in the future if arbitrage capital flows into the market gradually, as opposed to all at once.

This analysis is performed separately for S&P 500 and non-S&P 500 stocks listed on the NYSE, to see if institutional arbitrage activity to correct mispricing is more prevalent in the relatively larger stocks that comprise the index. In an attempt to remove non-stationarities, all variables are linearly detrended before their usage in the VAR. The VAR uses four lags as determined by the Akaike Information Criterion. Correlations between the VAR innovations and Granger causality tests appear in Table 13.

It can be seen that for S&P 500 stocks, there is bivariate Granger causality between turnover and the lagged return coefficient. In addition, turnover Granger-causes the longer-term momentum coefficients. Furthermore, all correlations between the VAR innovations are positive, though only the one between turnover and the lagged return is significant. For non-index stocks, while the correlations are all positive (and two are

significant) there is no evidence of Granger causality between the coefficients and turnover, which is consistent with the notion that institutions prefer larger stocks to conduct arbitrage activities.

Overall, the balance of this evidence suggests that trends in turnover have been influenced by increased arbitrage activity as revealed by higher sensitivity of turnover to past returns.

One important source of the increase in trading volume could be the increasing prevalence of algorithmic trading by hedge funds and other institutions.[24] Algorithmic trading refers to the use of computer algorithms to manage the trading process. The dramatic improvements in information technology has allowed algorithms to determine the optimal order submission strategy in order to minimize price impacts and trading costs. Algorithms dynamically monitor liquidity across different trading venues and choose optimal price and quantity pairs along with order submission strategies (limit versus market orders) to most efficiently execute orders.

The evidence in the preceding sections, from the decline in order sizes but the increase in number of orders, to the decline in transactions costs, to the increase in the information content of prices, to the increased trading activity in stocks with higher institutional holdings and the sensitivity of turnover to past returns all point to the increasing use of algorithmic trading by institutional traders.

VI. Conclusions

Share turnover has increased dramatically over the past several years. We explore the anatomy of this significant up-trend in aggregate trading activity. The increase is

[24] Algorithmic trading was non-existent in the early 1990s but is expected to represent about half of the trading volume by 2010. See "Ahead of the tape –Algorithmic Trading," Economist, March 10, 2007.

associated with more frequent smaller orders, which have progressively formed a larger fraction of trading volume over time. Institutions seem to be contributing more than retail investors towards the increase in volume because share turnover has increased the most for stocks with the greatest level of institutional holdings. Thus, institutions appear to breaking up orders into ever smaller increments before trading.

Dispersion in analysts' forecasts and implied volatility show no dramatic shifts in a manner consistent with the increase in turnover. However, the increase in the volatility of equity fund flows indicates that part of the turnover increase may be due to improvements in technology that allow for more frequent asset allocations by retail investors, that, in turn, lead to more trading by institutions acting as investing agents for investors. The exogenous decline in tick sizes provides strong support to the idea that the increased turnover is related to a decline in trading costs.

Variance ratio tests indicate that the increase in turnover appears is associated with greater production of private information, particularly in stocks with greater levels of institutional holdings. This indicates that institutions are trading more on private information in recent years due to lower trading costs. The cross-section of turnover has also changed, in that turnover has become more sensitive to past returns in recent years. This suggests that at least part of the rather dramatic recent rise in turnover might be attributed to quantitatively-oriented institutions such as hedge funds, which employ such variables in their trading strategies

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Table 1: Turnover averages, 1993-2005

This table presents the value-weighted NYSE average turnover (using market capitalizations as of the end of the previous year for weighting) in two subperiods from 1993 to 2005.

Panel A: 1993-1999

	S&P500	Non-S&P500
Mean	0.059	0.068
Median	0.059	0.065
Std. Dev.	0.009	0.013

Panel B: 2000-2005

	S&P500	Non-S&P500
Mean	0.093	0.099
Median	0.092	0.098
Std. Dev.	0.013	0.017

Table 2: Dollar trade size and number of transactions, before and after the end of 1999

This table presents the value-weighted average dollar trade size and number of transactions on the NYSE (using market capitalizations as of the end of the previous year for weighting) in two subperiods from 1993 to 2005.

Panel A: Dollar trade size ($millions)

	1993-1999	2000-2005
Mean	0.0824	0.0549
Median	0.0833	0.0448
Std. Dev.	0.0100	0.0207

Panel B: Number of transactions

	1993-1999	2000-2005
Mean	879.38	3530.50
Median	644.90	3393.32
Std. Dev.	559.94	930.20

Table 3: Small and large trades as a proportion of total dollar volume, before and after the end of 1999

This table presents the proportions of volume comprising large and small trades on the NYSE in two subperiods from 1993 to 2005.

Panel A: Proportion of dollar volume in trades less than $10,000

	1993-1999	2000-2005
Mean	0.0454	0.0824
Median	0.0436	0.0825
Std. Dev.	0.0099	0.0323

Panel B: Proportion of dollar volume in trades more than $10,000

	1993-1999	2000-2005
Mean	0.9546	0.9176
Median	0.9564	0.9175
Std. Dev.	0.0099	0.0323

Table 4: Effective Spreads for Small (≤$10,000) and Large (>$10,000) Trades, and Depth, before and after the end of 1999

This table presents the value-weighted average effective spreads for small (Panel A) and large (Panel B) trades and value-weighted mean depth (Panel C) on the NYSE (using market capitalizations as of the end of the previous year for weighting) in two subperiods covering 1993 to 2005.

Panel A: Small Trades

	1993-1999	2000-2005
Mean	0.0999	0.0311
Median	0.1110	0.0229
Std. Dev.	0.0207	0.0185

Panel B: Large Trades

	1993-1999	2000-2005
Mean	0.1099	0.0381
Median	0.1176	0.0280
Std. Dev.	0.0156	0.0239

Panel C: Depth (Shares)

	1993-1999	2000-2005
Mean	10607	3917
Median	11634	2938
Std. Dev.	3622	2328

Table 5: Cross-sectional Regressions around 16th and decimal shifts, for six months before and after the shift in tick size

In these regressions, the dependent variable is the average change in turnover across the two subperiods; and the explanatory variables are the average change in the proportional quoted spread (ΔRQSPR) and in the volatility (standard deviation) of returns.

Panel A: Sixteenth shift

Variable	Coefficient	t-statistic
ΔRQSPR	-0.06524	-5.96
ΔVolatility	0.09254	19.88

Panel B: Decimal Shift

Variable	Coefficient	t-statistic
ΔRQSPR	-0.04164	-4.80
Δ Volatility	0.06004	15.79

Table 6: Average turnover in percent per month across stocks stratified into quintiles by institutional holdings

All stocks are divided into five groups by the level of institutional holdings in the immediately preceding quarter. Then, value-weighted average total turnover, small order turnover and large order turnover are presented for these quintiles (using market capitalizations as of the beginning of the relevant year for weighting).

Panel A: Total turnover

	Institutional Holdings Group				
	Smallest	2	3	4	Largest
1993-1999	3.408	4.652	5.422	6.225	7.012
2000-2005	4.645	6.844	8.174	9.272	10.673

Panel B: Turnover due to small (≤$10,000) orders

	Institutional Holdings Group				
	Smallest	2	3	4	Largest
1993-1999	0.571	0.562	0.523	0.471	0.403
2000-2005	1.261	1.655	1.826	1.915	2.013

Panel C: Turnover due to large (>$10,000) orders

	Institutional Holdings Group				
	Smallest	2	3	4	Largest
1993-1999	2.842	4.108	4.995	5.843	6.698
2000-2005	3.399	5.232	6.401	7.420	8.695

Table 7: Average turnover in percent per month across stocks stratified into quintiles by institutional holdings and firm size

Stocks are divided into 25 groups by the level of institutional holdings in the immediately preceding quarter and average market capitalization s of the beginning of the relevant year. Then, value-weighted average total turnover, small order turnover and large order turnover are presented for these quintiles (using market capitalizations as of the beginning of the relevant year for weighting).

Panel A: Total turnover

Sub-Period: 1993-1999

	Smallest	2	3	4	Largest
Firm Size	Institutional Holdings Group				
Smallest	4.274	4.950	5.206	5.559	6.184
2	3.486	4.827	5.759	6.072	6.764
3	3.244	4.976	5.842	6.883	7.685
4	3.314	4.981	6.045	6.874	8.070
Largest	2.846	3.736	4.383	5.629	6.409

Sub-Period: 2000-2005

	Smallest	2	3	4	Largest
Firm Size	Institutional Holdings Group				
Smallest	4.686	6.125	7.499	7.781	9.194
2	4.550	6.870	7.512	8.816	10.282
3	5.026	7.676	9.142	10.165	11.654
4	4.879	7.657	9.598	10.759	12.124
Largest	4.085	5.891	7.118	8.838	10.113

Table 7 (Continued)

Panel B: Turnover due to small (≤$10,000) orders

Sub-Period: 1993-1999

	Smallest	2	3	4	Largest
Firm Size	Institutional Holdings Group				
Smallest	1.390	1.186	1.017	0.855	0.791
2	0.692	0.689	0.661	0.599	0.519
3	0.371	0.494	0.483	0.462	0.367
4	0.308	0.362	0.363	0.306	0.269
Largest	0.161	0.145	0.134	0.144	0.128

Sub-Period: 2000-2005

	Smallest	2	3	4	Largest
Firm Size	Institutional Holdings Group				
Smallest	2.054	2.533	2.828	2.745	3.053
2	1.640	2.287	2.364	2.612	2.768
3	1.382	1.875	2.096	2.222	2.277
4	0.947	1.264	1.425	1.454	1.382
Largest	0.283	0.319	0.415	0.540	0.585

Panel C: Turnover due to large (>$10,000) orders

Sub-Period: 1993-1999

	Smallest	2	3	4	Largest
Firm Size	Institutional Holdings Group				
Smallest	2.892	3.765	4.189	4.704	5.393
2	2.798	4.138	5.099	5.473	6.245
3	2.881	4.490	5.373	6.428	7.319
4	3.007	4.625	5.734	6.582	7.839
Largest	2.688	3.679	4.638	5.939	6.681

Sub-Period: 2000-2005

	Smallest	2	3	4	Largest
Firm Size	Institutional Holdings Group				
Smallest	2.640	3.593	4.672	5.036	6.141
2	2.914	4.598	5.148	6.204	7.520
3	3.661	5.818	7.095	7.944	9.386
4	3.939	6.407	8.236	9.345	10.787
Largest	3.842	5.741	6.855	8.572	9.642

Table 8: First order daily serial correlations in order imbalances for stocks stratified into quintiles by institutional holdings

All stocks are divided into five groups by the level of institutional holdings in the immediately preceding quarter. Then, cross-sectional averages of daily serial correlations in order imbalance (in number of shares) are presented for these quintiles.

Panel A: Total order imbalance

		Institutional Holdings Group				
	Overall	Smallest	2	3	4	Largest
1993-1999	0.103	0.108	0.103	0.103	0.101	0.097
2000-2005	0.161	0.152	0.158	0.162	0.166	0.165

Panel B: Order imbalance due to small (≤$10,000) orders

		Institutional Holdings Group				
	Overall	Smallest	2	3	4	Largest
1993-1999	0.256	0.194	0.245	0.284	0.291	0.252
2000-2005	0.232	0.211	0.241	0.249	0.231	0.224

Panel C: Order imbalance due to large (>$10,000) orders

		Institutional Holdings Group				
	Overall	Smallest	2	3	4	Largest
1993-1999	0.087	0.078	0.082	0.089	0.092	0.092
2000-2005	0.136	0.108	0.130	0.142	0.149	0.151

Table 9: Potential Determinants of Turnover, 1993-2005

The panels below present various potential determinants of NYSE turnover across the sub-periods from 1988 to 2005. The panels respectively consider value-weighted monthly open/close and close/open variance ratios, value-weighted analyst forecast dispersion, the implied volatility of S&P 500 index, measured by the published VIX, and weekly aggregate money flows into equity funds. (Value-weights use market capitalizations as of the end of the previous year.)

Panel A: Dispersion in Analyst Forecasts

	1993-1999	2000-2005
Mean	0.0513	0.0573
Median	0.0453	0.0493
Std. Dev.	0.0261	0.0268

Panel B: Implied volatility (VIX)

	1993-1999	2000-2005
Mean	18.549	20.890
Median	17.090	19.505
Std. Dev.	6.668	6.549

Panel C: Weekly Equity Fund Flows (billions of dollars)

	1993-1999	2000-2005
Mean	1.917	1.117
Median	1.981	1.276
Std. Dev.	2.621	3.588

Table 10: Variance Ratios, 1993-2005

The panels below present averages of per hour open/close to close/open variance ratios for NYSE stocks across the sub-periods from 1993 to 2005. The ratios are computed monthly, then value-weighted using market capitalizations as of the end of the previous year for weighting. Panel A presents summary statistics on these ratios for the full sample. Panel B presents the statistics for five groups sorted by the level of institutional holdings in the immediately preceding quarter.

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Panel A: Full sample

	1993-1999	2000-2005
Mean	9.579	13.085
Median	7.968	11.690
St. Dev.	6.099	7.490

Panel B: By institutional holdings quintile

	Small		2		3		4		Large	
	93-99	00-05	93-99	00-05	93-99	00-05	93-99	00-05	93-99	00-05
Mean	13.136	12.353	10.297	11.102	8.605	12.538	8.496	15.605	10.479	16.877
Median	10.845	11.107	8.272	10.162	7.502	11.474	6.733	13.268	8.846	14.854
St. Dev.	9.440	7.637	7.217	6.276	5.788	7.231	4.934	11.514	7.282	10.175

Table 11: Cross-Sectional Regressions for Turnover

This table presents coefficients of past absolute return (LARET) and past absolute two to six month return (LARET26) in the cross-sectional regression of monthly turnover of NYSE stocks on these variables. The sample period is 1993 to 2005.

Panel A: One-month return (LARET) coefficient

	1993-1999	2000-2005
Mean	17.72	21.88
Median	17.90	20.10
Std. Dev.	5.08	10.46

Panel B: Past two-to six-month return (LARET26) coefficient

	1993-1999	2000-2005
Mean	7.79	8.49
Median	7.85	7.86
Std. Dev.	2.27	3.82

Table 12: Panel Regressions for Turnover

This table presents coefficients of past absolute return (LARET) and past absolute two to six month return (LARET26) in a panel regression of monthly turnover on these variables. The approach corrects for serial correlation and heteroskedasticity. The sample period is 1993 to 2005 and the cross-section consists of the 724 NYSE-listed firms that were present in the sample every month. The variable Post1999 takes on the value one in the 2000-2005 period and zero otherwise.

Variable	Coefficient	t-statistic
LARET	5.032	12.87
LARET*POST1999	16.225	29.73
LARET26	1.759	9.80
LARET26*POST1999	6.658	24.75

Table 13: Vector autoregressions for turnover determinants

These VARs pair detrended turnover of NYSE stocks with detrended coefficients of past absolute one-month return (LARET) and past absolute two to six month return (LARET26) in cross-sectional regressions of monthly turnover on these variables (* denotes significance at the 5% level)

Panel A: S&P 500 turnover

Correlations in VAR innovations		
	Turnover	LARET
LARET	0.258*	
LARET26	0.114	0.028

Granger Causality test p-values (for the null that row variable does not cause column variable)			
	Turnover	LARET	LARET26
Turnover	-	0.021	0.021
LARET	0.048	-	<0.01
LARET26	0.527	0.073	-

Panel B: Non-S&P 500 turnover

Correlations in VAR innovations		
	Turnover	LARET
LARET	0.268*	
LARET26	0.233*	0.062

Granger Causality test p-values (for the null that row variable does not cause column variable)			
	Turnover	LARET	LARET26
Turnover	-	0.922	0.115
LARET	0.934	-	<0.01
LARET26	0.125	0.039	-

Figure 1. Average Turnover, 1993-2005,
S&P500 stocks and other stocks

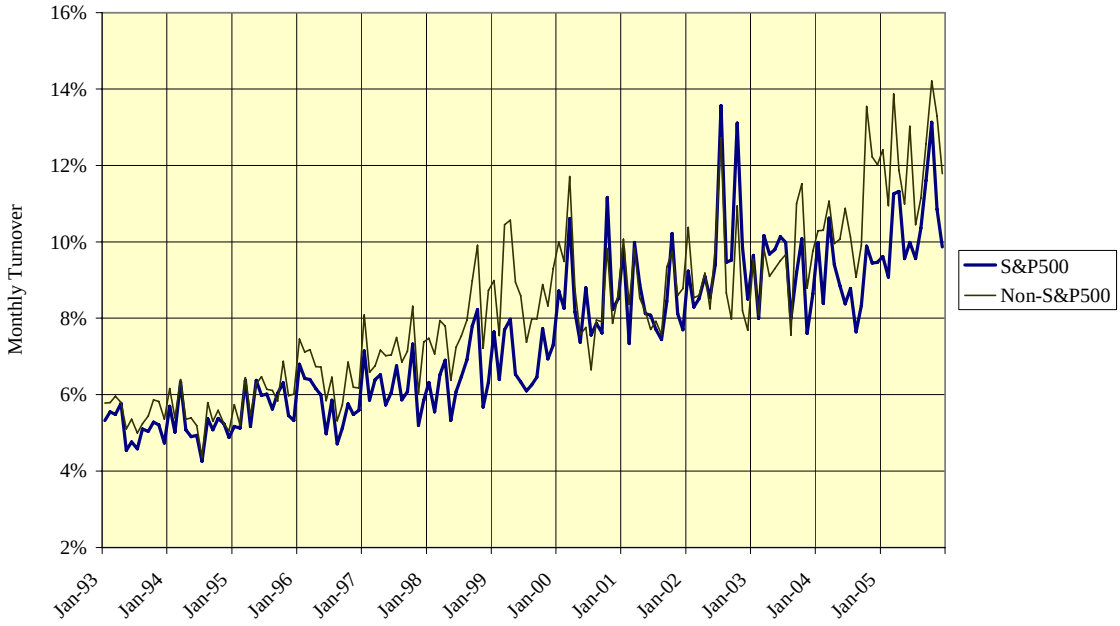

Figure 2-A. Average Dollar Trade Size, 1993-2005

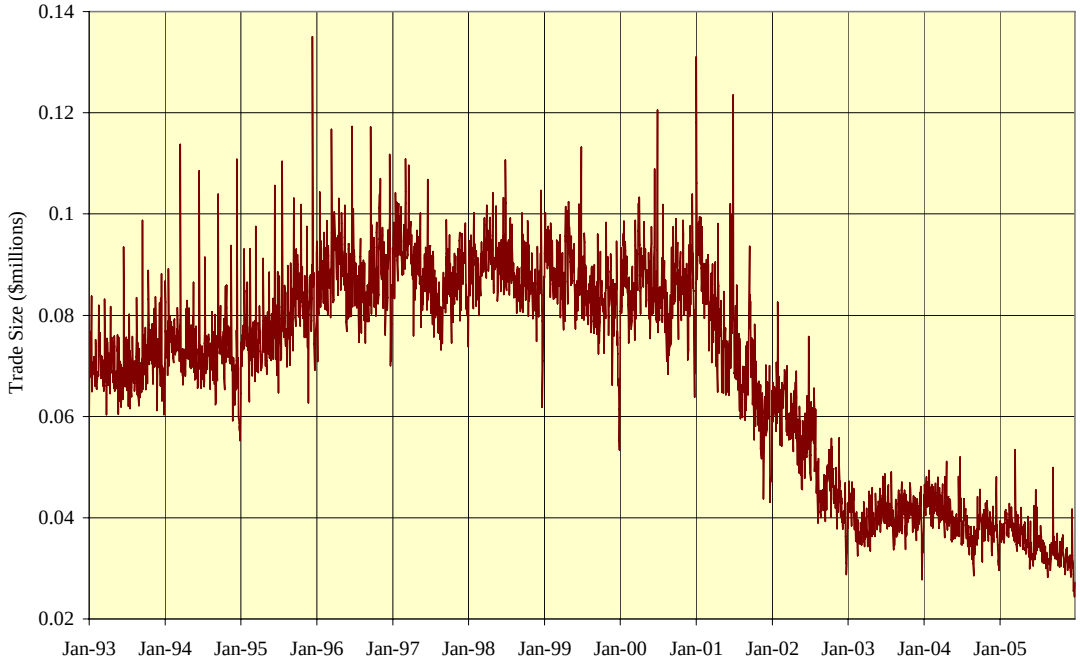

Figure 2-B. Average Number of Daily Transacations per Stock, 1993-2005

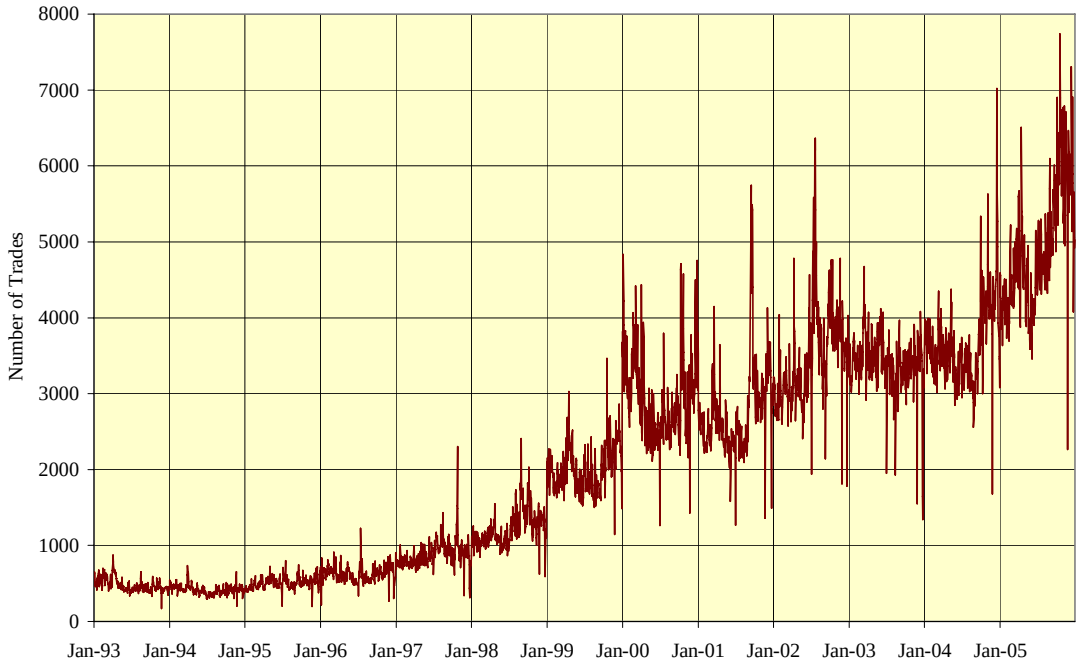

Figure 3-A. Percentage of Trades less than $10,000, 1993-2005

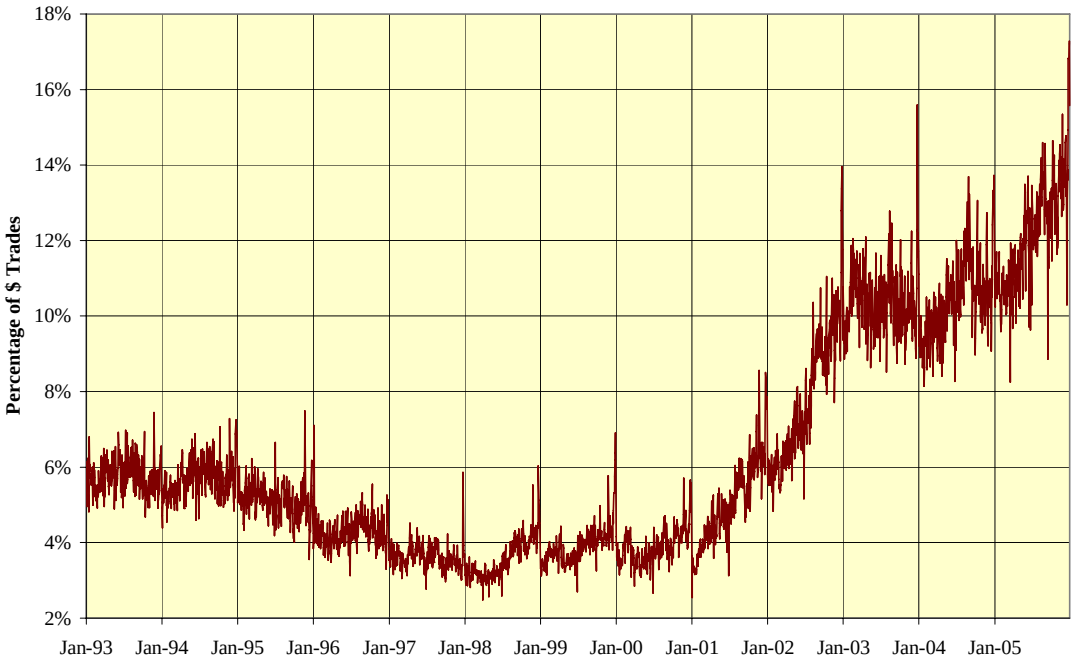

Figure 3-B. Percentage of Trades greater than $10,000, 1993-2005

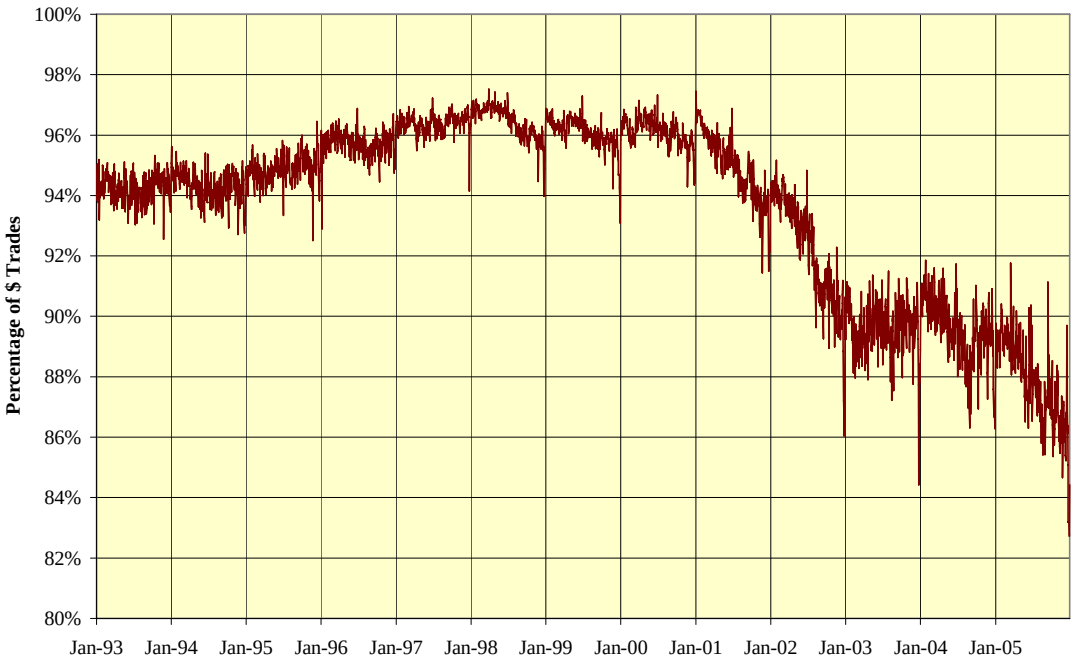

Figure 4-A. Value-weighted proportional effective spreads, small orders (<$10,000) and large orders (>$10,000), 1993-2005

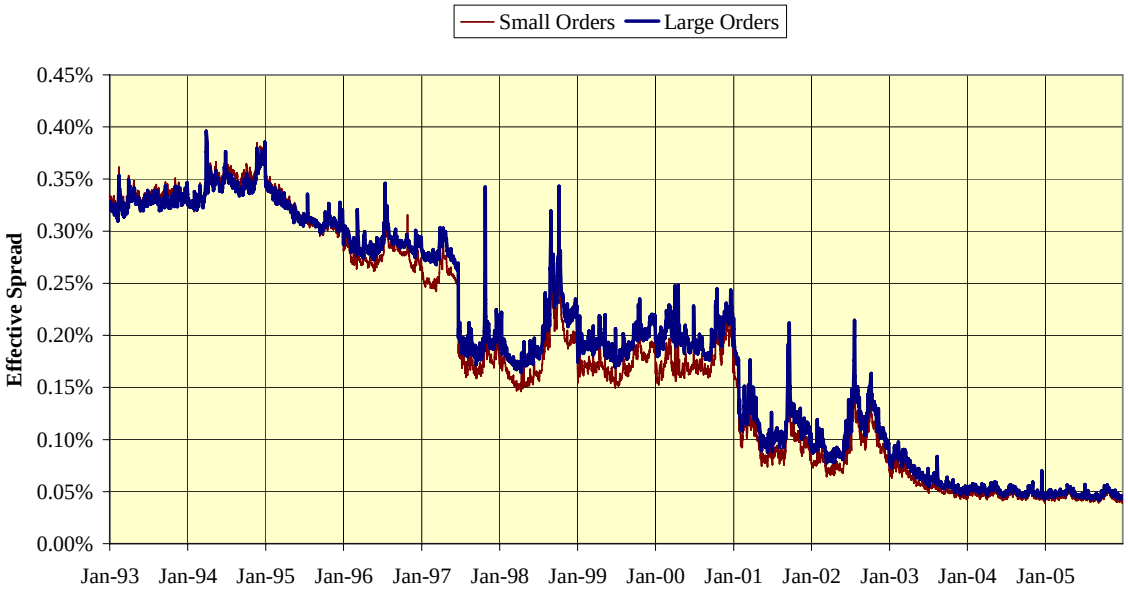

Figure 4-B. Depth, Value-Weighted, 1993-2005

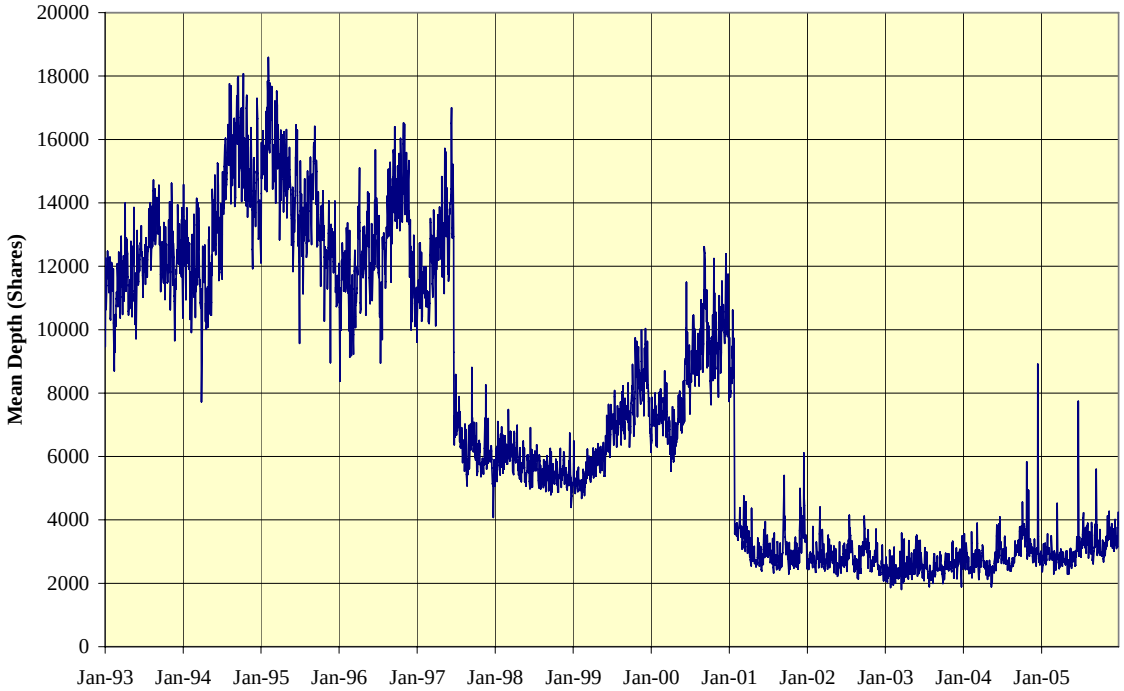

Figure 5. Value-weighted average turnover, 1993-2005,
by lowest to highest institutional ownership holding groups

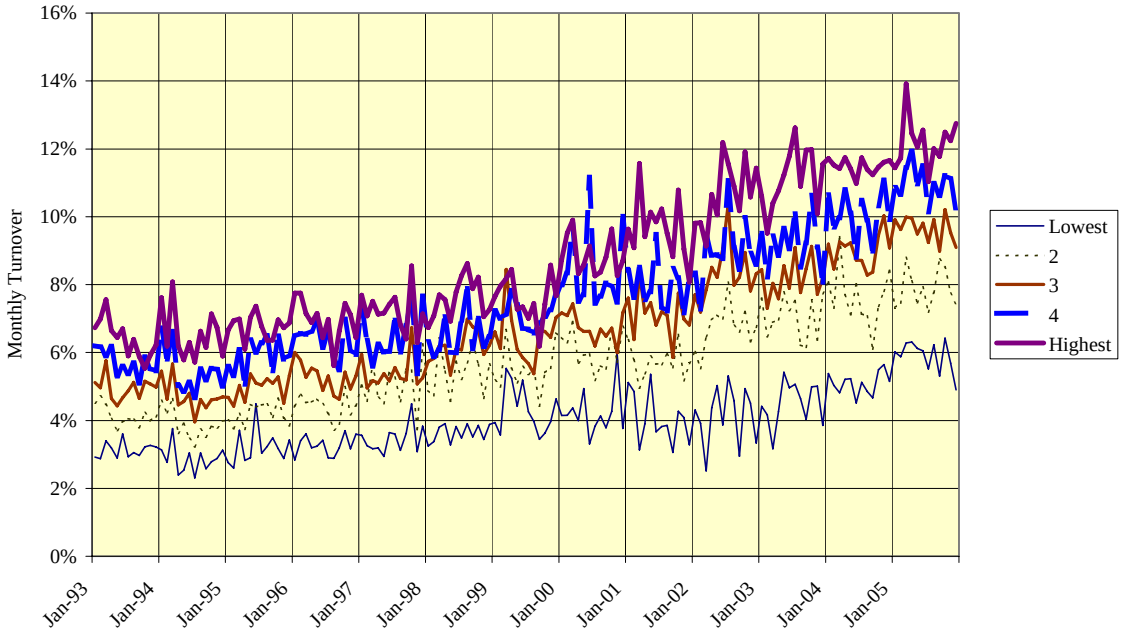

Figure 6. Variance Ratio per Hour, Open to Close/Close to Open
1993-2005, Within Calendar Months

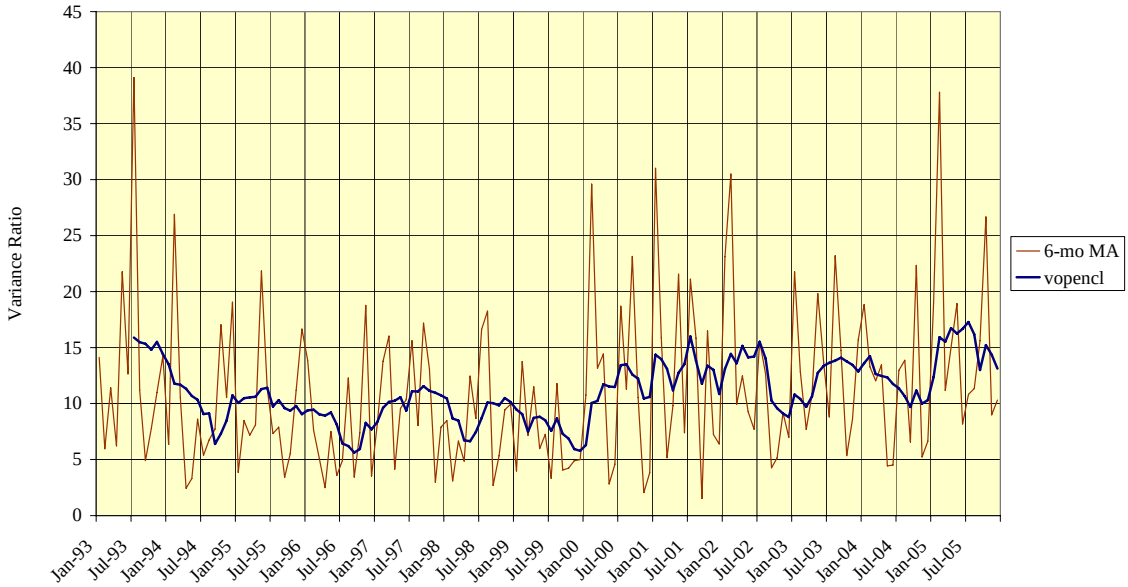

Figure 7. Turnover on absolute return-1 and absolute cumulative return -2 to -6