Liquidity providers' valuation of anonymity: The Nasdaq Market Makers evidence

Kheira BENHAMI*

November 2006

Abstract

Since December 2002, market makers have the ability to enter quotes in an anonymous way. To what extent do market makers value the ability to place quotes anonymously? Would the introduction of anonymity on Nasdaq lead to a more competitive provision of liquidity by market makers as suggested by Simaan, Weaver and Whitcomb (2003)? We investigate this point by looking at market makers' reactions and changes in quoting behavior following the introduction of this new anonymity feature. We find that market makers quotes posted anonymously are 8% of the time alone at the inside, that they reach this "inside alone" position by more actively reducing the best quotes than regular quotes and that the quoted depth they offer is more frequently higher than the 100 shares minimum required. However, we did not find evidence that anonymous quotes improved more the best quotes. Turning to the price discovery process, using the Hasbrouck (1995) information share methodology, we find that anonymous quotes contain information. However, their informational content is quite small with respect to other type of quotes: their information share averages 19% when it reaches 40% for non anonymous quotes and 56% for ECN ones. This thus suggests that anonymity is not the only answer to the lack of quote competition observed between market makers and that other practices such as internalization, preferencing or payment for order flow may play a non negligible role.

Keywords: Anonymity, Market Makers, ECNs, competition, quoting behavior.

*Université de Toulouse (GREMAQ) Manufacture des Tabacs 21, Allée de Brienne, bureau MF201 31000 Toulouse FRANCE . Email: kheira.benhami@univ-tlse1.fr.

1. INTRODUCTION

Since 1997, The Nasdaq Stock Market has experienced profound changes. The introduction of the "Order Handling Rules" and the integration of Electronic Communication Networks (ECNs) have indeed substantially changed the competitive landscape for Nasdaq listed stocks. Since then market shares of these ECNs did not stop their rise.[1]

In a previous study, Simaan, Weaver and Whitcomb (2003), have shown that ECNs have even been elected by market makers to post their more competitive quotes. At the core of this attractiveness lies the ability to post quotes anonymously. This made them lead to the following conclusion :"*making the level of pre-trade transparency on Nasdaq more opaque by allowing anonymous quotes could improve price competition and narrow spread further"*. To what extent do market makers value the ability to place quotes anonymously? Would the introduction of anonymity on Nasdaq indeed lead to a more competitive provision of liquidity by market makers?

On December 2002, Nasdaq completed the roll out of its new "all electronic" trading platform, SuperMontage. This new trading platform features a book which gathers market makers and ECNs best quotes. Among the features of this new trading system, Nasdaq authorities have introduced the ability to post quotes anonymously. In a first step, anonymity was preserved only pre-trade as counterparties identities were disclosed immediately after the trades. In October 2003, the anonymity feature was enhanced and traders IDs remained concealed even after the conclusion of the trade. This natural experiment gives us the opportunity to empirically investigate if Simaan et al. (2003) conjecture was right.

A number of past studies have examined the various effects of different anonymity regimes. However, only few of them have investigated the impact of anonymity from the point of view of liquidity providers. Moreover, they lead to mixed results. Indeed, Gemmill (1996) suggests that it is more difficult for dealers to lay off positions in a transparent market that reveals dealer inventories as other traders will engage in spoiling tactics. In the same spirit, Heidle, Huang (2002) argue that greater anonymity can lead to larger spreads because intermediaries have a harder time to distinguish informed trades. That is, if dealers are unable to segregate the informed traders from the liquidity traders, the resulting equilibrium is one where the bid-ask spreads are wider than in an environment where institutional design permits the segregation of the two parties. In contrast Naik et al. (1999) suggest that trade transparency can reduce inventory costs. They contend that greater transparency may allow identifying inventory management trades more effectively and, thereby, increasing other liquidity providers' willingness to publicly display trades. Lyons (1996) concurs that providing potential liquidity providers with more order flow information can induce them to share risk amongst one another. Even empirical studies, seem not to

[1] At the end of 2002 they averaged almost 50% of the market shares for Nasdaq listed stocks.

reach a clear consensus. To test empirically the impact of anonymity, several attributes have been considered.

A first type of studies considers the informational content of anonymous quotes. Among them, Grammig, Schiereck and Theissen (2001), using data from the German stock market, examine the relation between the degree of traders' anonymity and the probability of information based trading. They find that the probability of informed trading is significantly lower in the floor based (non anonymous) trading system. Moreover, they document that the size of the spread and the adverse selection component are positively related to the estimated probabilities of information-based trades. By contrast, studying interdealer trades in the London Stock Exchange, Reiss, Werner (2005) find, on contrary, that adverse selection is less prevalent in the anonymous brokered markets and that informed interdealers trades tend to migrate to the direct non anonymous public market.

A second type of study examines the effect of the two types of anonymity levels that might be available: pre-trade anonymity as opposed to post-trade anonymity. These studies concentrate on the Euronext Paris case when it first switched to post-trade anonymity for actively traded stock and then became completely anonymous in April 2001. Interestingly, these studies go on the opposite direction suggesting that post-trade and pre-trade anonymity have strikingly different effects. Indeed, Waisburd (2003) focuses on the effect of revealing liquidity suppliers' IDs after a transaction occurred. He finds that the average bid-ask spread is larger and quoted depth is smaller in the post-trade anonymity regime consitent with Naik et al. (1999) and Lyons (1996). The source of improved liquidity appears to be a reduction in average inventory control. This evidence is consistent with the notion that the ability to identify inventory management trades fosters risk sharing. Another study was conducted by Foucault, Moinas and Theissen (2004). Through a theoretical model disentangling informed investors from non informed ones, they argue that in a non anonymous environment, uninformed quote setters would learn from observing the quotation behavior of informed traders and consequently "free ride" on this information by setting quotes that are slightly more aggressive than those posted by informed quote setters. They thus conclude that in an attempt to avoid this, quote setters will engage in "bluffing" strategies in which they will set wider spreads than appropriate. In an anonymous market, there is no need for quote setters to engage in these bluffing strategies as they are not visible to uniformed quote setters. Hence they will always quote a competitive spread. They empirically test their predictions using the Euronext Paris implementation of pre-trade anonymity and find that the switch to anonymity has been followed by a reduction in Bid-ask spread and that the size of the spread contains information.

Some studies have more particularly analyzed Nasdaq and ECNs. Barclay Hendershott and Mc Cormick (2003) study competition between ECNs (anonymous) and Nasdaq dealers (non anony-

mous). They find that ECNs are more active when there are greater informational asymmetries, and when trading volume and stock-return volatility are high. They also find that ECN trades have greater permanent price impacts than dealer trades. The authors conclude that anonymous ECNs attract informed traders for Nasdaq listed stocks as they offer speed of execution, and pre- and post-trade anonymity. Simaan, Weaver and Whitcomb (2003) argue that a transparent market setting enables traders to enforce informal collusive agreements to quote wider spreads. That is, anyone setting narrower spreads can be identified and reprimanded by other quote setters. They consequently argue that spreads will be narrower in an anonymous environment. They provide evidence consistent with their proposition by demonstrating that Nasdaq dealer quotes posted through anonymous ECNs are tighter than dealer quotes posted through Nasdaq.

Our study differs from previous ones in several dimensions. Grammig et al.(2001) and Reiss, Werner (2004) compare an electronic system (anonymous) and a floor based one (non anonymous). They thus consider two different market structure and other factors such as rapidity of execution may also explain the observed differences. With SuperMontage, the Nasdaq dealer market turned to an all electronic one and offers a system with high a level of automation which mimics what ECNs offer.[2] The second bulk of studies considering Euronext Paris gives some empirical evidence on the role of anonymity (pre and post trade) when anonymity is imposed to liquidity providers. In the present setting, this is not the case. Nasdaq dealers have the ability to choose between different regimes of identity disclosure. In this sense, this study is closer to the Simaan, Weaver and Whitcomb (2003). However, since the Simaan et al. (2003) study, the competitive landscape for Nasdaq stocks have experienced dramatical changes (automation, decimalization). We will try to evaluate how these changes have affected market makers quoting behavior and to highlight the role played by the new anonymity feature. Lastly, our framework allows us to complete their analysis by distinguishing between pre-trade and full anonymity. Indeed, as stated before, at the beginning of SuperMontage, only pre-trade anonymity was guaranteed as counterparts IDs were immediately disclose after the trade. The preservation of anonymity after the trade was introduced only one year later. This gradual implementation allows us to add one dimension to our study: the measure of the marginal impact of post-trade anonymity given that pre-trade anonymity was already available. By opposition to Waisburg (2003) who measures post-trade anonymity whereas pre-trade one is not available and Foucault et al. (2004), who measure the impact of pre-trade anonymity given that post-trade one is already available.

Analyzing the behavior of quote setters participating to the montage we find that market makers quotes posted anonymously are 8% of the time alone at the inside, that they reach this “inside alone” by more actively reducing the best quotes than regular quotes and that the quoted depth

[2] A study published by Nasdaq in the week following the new trading platform roll out indicates that the time to first execution of an order is less than one second. This is a great technical improvement as compared to the average thirty seconds observed on the former system Selectnet.

they offer is more frequently higher than the 100 shares minimum required. However, contrary to the Simaan, Weaver and Whitcomb (2003), we did not find evidence that anonymous quotes improved more the best quotes. Moreover, the introduction of full anonymity do not seem to have any impact on the quote setting behavior of market makers. Turning to the price discovery process, we find that anonymous quotes contain information. However, their informational content is quite small with respect to other type of quotes: their information share averages 19% when it reaches 40% for non anonymous quotes and 56% for ECN ones. Collectively, our results suggest that even though the inability to post quotes anonymously on Nasdaq platform was presented as an explanation to the lack of competition between market makers, its implementation did not seem to cause the reverse effect. Introducing anonymity on Nasdaq platform did not lead to an increase in competition between market makers.

The rest of the paper is organized as follows: First we present the new institutional framework in which market makers now manage their business. After having detailed the data, the methodology employed for this study and our empirical findings in sections 3 and 4, section 5 is devoted to the price discovery process and the informational contribution of anonymous orders. Section 6 concludes.

2. INSTITUTIONAL FRAMEWORK

In this section, we describe various institutional and regulatory constraints imposed for Nasdaq listed stocks trading. Beginning with a description of Nasdaq dealers main competitors, ECNs, we will then describe the feature of the new trading platform and try to highlight some potential empirical findings.

Electronic Communication Networks are basically systems with electronic order books matching buy and sell trading interests without a market maker intervention. They were integrated into the market in 1997 with the Order Handling Rules. ECNs differ from traditional market makers in various dimensions and offer several potential benefits to investors. First, ECNs typically offer an advantage in the speed of execution. By contrast, when a broker submits a customer's order to a market maker, it can take between from 30 seconds to three minutes to execute the order. Indeed, traditional orders are sent first to a broker either electronically or over the phone, who determine the market where they will be sent for execution. The other appreciated feature offered by ECNs is their ability to offer total anonymity to quote setter. This anonymity is preserved all along the trading process.

Facing an increase level of competition from these ECNs, Nasdaq authorities have released their new trading platform SuperMontage in December 2002. Like an ECN, SuperMontage features a book, which gathers Market Makers and ECNs best quotes. ECNs can choose to accept auto-

execution or to be integrated via a delivery mechanism. It also allowed users to choose price time, price size and price fee priority on an order-by-order basis. Finally, market participants are able to enter orders anonymously. Those anonymous orders, designed as "non-attributable" orders do not display with the market participant identifier (MPID). Instead, they are aggregated and displayed under the special MPID "SIZE". After the adoption of a full anonymity regime, transaction reports indicate the details of transactions, but do not reveal contra parties identities. This changes in Nasdaq functioning has a direct impact on market making activity. Indeed, over our period of study, a market maker receiving an order had more options to choose from. She can either:

(i) execute the order internally,

(ii) change her inside quote to reflect this order: she can do it through her market maker ID or anonymously through the MPID "SIZE",

(iii) deliver it to another market participant, including ECNs.

The two last options offered to market makers provide access to anonymity: one via Nasdaq trading platform, another via ECNs.
Why would dealers seek anonymity? One argument is that anonymity helps market makers when working large positions. Indeed, some market makers are known to treat frequently with institutional investors which are usually superior informed agents. After a trade with such agents, the market maker may have difficulties to unwind its position without a significant price impact. However, by doing it anonymously, this impact can be limited. Thus, dealers may seek anonymity to reduce the price impact of trades designed to unwind their positions. Another argument exposed by Simaan et al. (2003), is the threat of retaliation. According to them, the revelation of dealers'identities enforce implicit collusion to keep spreads wider. If the collusion argument still holds, this gives them another way to avoid the threat of retaliation from other dealers. Indeed, they used to post their spread narrowing quotes on ECNs rather than on the Nasdaq Montage because they could do it anonymously. Now, that this anonymity feature is directly available on SuperMontage we would expect to have a significant uses of anonymity facility by market makers. These arguments are essentially available after the full implantation of anonymity on the new trading system. Indeed, until then at least, ECNs were still presenting a non negligible advantage over SuperMontage: they preserved the anonymity through the whole trading process.

The next section describes the data and the approach adopted to empirically assess market makers' reaction to anonymity.

3. THE DATA

This study uses The Nasdaq Trade and Quote data set. Our sample contains all SuperMontage trades and quotes for 75 Nasdaq National Market stocks during the normal trading hours, from 9:30 a.m. to 4:00 p.m.[3] The sample period spans 10 trading days in September 2003, when only pre-trade anonymity was offered, and 10 trading days in November 2003. During this second period, the montage offered full anonymity.

This database presented two main drawbacks. First, every quote and quote updates from all market participants are not available. Indeed, we do not have detailed information for all ECNs not participating to the SuperMontage.[4] At the time of our study there were nine ECNs. Among them, one of the largest has refused to participate to SuperMontage. Island was the first to migrate its order flow to the Cincinnati Stock Exchange in 2002. Instinet[5] and Attain have chosen to represent their trading interests on the Alternative Display Facility. And lastly, Archipelago has merged with the Pacific Stock Exchange and has become the first ECN to acquire an exchange status in April 2003. They however appear in the National Best Bid and Offer files which only precise which market center is responsible for the best quotes.

The second drawback is that whereas the database allows us to make the distinction between trades executed in and outside SuperMontage, it does not allow us to distinguish trades that were executed via SuperMontage execution systems from other trades. Typically those trades are the one internalized by market making firms or ECNs that have decided to participate to SuperMontage but that does not route all their order flow to the platform.

To conduct our analyses, we adopted the same methodology as Simaan et al.(2003). First we disaggregate our sample to obtain the best quotes posted non anonymously by market makers ("regular market maker quotes"), quotes posted through the SIZE identifier ("anonymous quote") and quotes posted via ECNs. One important feature of Nasdaq SuperMontage is that only market makers and participating ECNs are allowed to post orders on the platforms.[6] We thus are sure that only market makers quotes are involved in our analysis when considering attributed and non attributed quotes. However, contrary to Simaan et al. (2003), we are unable to determine to what extent ECNs quotes posted in the montage reflect market makers quotes. First, we do not

[3]These stocks are all Nasdaq 100 comon stocks that remained in the index over the whole 2003 year.

[4]They judged that Nasdaq was trying to capture their order flow through anticompetitive practices.

[5]At the time of the study, Island and Instinet, despite their announced merger, had not yet combined their order books.

[6]Anonymous ECNs, however, also do not offer uniform open access. For example, Instinet has continued to limit access to dealers and select institutional traders while the Island ECN is open to virtually everyone. Moreover, since February 2003, Order entry firms are also allowed to post orders in SuperMontage, but only anonymously. An order-entry firm is a broker dealer which only acts on an agency basis. Thus it is not a market maker. However a study realized by Nasdaq authorities show that their participation in the Montage is limited (1.5% of the volume in April 2003). We will thus consider that anonymous quotes quasi exclusively originate from market makers.

have access to detailed database when considering non participating ECNs. As stated before, Instinet, which was identified as the main source of market makers quotes posted via ECNs, has decided not to participate to SuperMontage. Moreover, most ECNs have seen their number and their variety of quote setters increased in such a way that even with the data it might have been difficult to assert which ECN targets which types of agents. The aim of this study is to try to characterize market makers use of anonymous orders in the new trading platform. We will thus use ECNs quotes only for benchmark purpose.

The last treatment applied to the data was to determine trade direction. Nastraq database does not provide the direction of the trade. We applied Lee and Ready (1991) algorithm to infer it. In our case, a trade was classified as buyer initiated when its price is strictly greater than all of the quote midpoints available during the second in which it took place and as seller initiated in the reverse case. When trades occur between the lowest quote midpoint and the highest quote midpoint available during the second of the trade, the so-called tick rule was used.

4. EMPIRICAL RESULTS

Quote setting analysis

This part of the study concentrates on the analysis of SuperMontage order flow. Table 1 provides daily descriptive statistics for the stocks in our two samples. Our sample includes 4.88 millions of trades in September 2003 and 4.24 millions in the November 2003 sample.We disaggregated our sample according to the total volume traded during our sample period study to highlight some potential patterns according to liquidity level. The high volume stocks represents the 25 most traded stocks in our sample. The 25 next represent the medium category and the 25 least traded constitute the low volume category. The number of transactions for the most liquid stock (high volume category) is more than 3 times and 8 times as high as the number of transactions for the least liquid stock (medium and low volume categories). The average trading size is 536 shares in September and stays stable in November as it averages 534 shares. Once again, high volume stocks exhibits higher trade size. We notice that all categories of stocks have seen their average number of trades and average trade size decreasing slightly in the second period of our sample. To assess the importance played by anonymous quotes on the new trading platform, we first investigate their position with respect to the best quotes. Table 2 reports the time weighted presence at the best quotes by type of quote setter for each volume category. The results show that market makers are frequently away from the best quotes. The proportion of quotes that are neither at the best ask nor at the best bid averages 22%. These results are consistent with the one of Chun, Zhao (2004), who show that the majority of quotes posted by NASDAQ dealers are non competitive . On contrary, ECNs quotes match more frequently the best quotes. The majority

(46.74%) of their quotes are at both best ask and best bid limits. Moreover, they present the least percentage of non competitive quotes (only 9%). When we turn to anonymous quote setters, we can see that they exhibit the higher percentage of quotes away from the best quotes as it averages 34%. We also observe that contrary to the two other types of quote setters, anonymous quotes are more frequently at only inside ask or inside bid than at the best ask and bid limits. This result suggests that anonymous quotes are essentially used to narrow best quotes on one side of the market only. The results presented before are accentuated as the volume traded increase. The proportion of non competitive quotes ranges from 16% for high volume stocks to 50% for low volume ones. We observe the same tendency for other market participants. Panel B of Table 2 reflects the same analysis conducted once the full anonymity has been adopted on Nasdaq. We observe the same patterns as the one exposed for panel A. We notice that the rate of non competitive quotes decreases in the post period for anonymous quotes. However, the amplitude of these changes is limited, decreasing only by 2 points.

An accurate measure of the contribution of various quotes setters to the narrowing of spreads is given by the percentage of time each type of quote is alone at the inside. This measure initially introduced by Barclay et al. (1999), is central to Simaan et al. (2003) study. According to them, given their "threat of retaliation" argument, market makers tend to have a higher propensity to quote competitively if they can do so anonymously. Corroborating this prediction, they find that Market makers actively go inside alone on ECNs more frequently than with regular Nasdaq market makers quotes. We apply the same reasoning to our sample to see if we reach the same conclusion regarding quoting behavior via anonymous SIZE quote. A quote setter is reputed alone at the inside when no other type of market participant is at the inside. In the same line of argument, another interesting point to investigate is whether these "alone at the inside" positions arise from active quoting behavior. Indeed, being alone at the inside does may not be voluntarily. One quote setter may reach the best quotes only because other market participant worsened its quotes following the execution of an order, for example. In the best case this results in no change on the inside bid or ask, while in the worst case this results in a decrease in the best quotes. However, in neither case, this situation concurs in reducing the quoted spread in the platform. Obtained results for our sample are presented in tables 3 and 4. Table 3 presents the percentage of time a quote setter is alone at the inside, and table 4 the percentage of time an "alone at the inside" position resulted from active quoting. We find that overall, in the first sample (panel A), anonymous quotes are alone at the inside (bid or ask) around 7% of the time. This result is far lower than the one find by Simaan et al (2003). Indeed, on average, market makers quotes posted via ECNs exhibited an "alone at the inside quote" position 19% percent of the time. In our sample, ECNs are market participants which reach more frequently this status. On average they are alone at the inside 25% of the time. Regular market makers quotes exhibit

an average of 17%. We observe a reverse pattern as the one obtained previously when we turn to an analysis by category of volume: the higher the volume the lower the percentage of time a quote setter is alone at the inside. Panel B analysis shows that after the introduction of post-trade anonymity, anonymous quotes experienced higher occurrence of alone at the inside quotes as their percentage reaches 9% in November 2003. This increase, though modest, is significant at a one percent level. In the same period, regular quotes did not experienced significant changes. On contrary, ECNs ones have seen their percentage decreasing to an average of 23%. All These changes affect similarly all trading volume categories.

Turning to table 4, we see that when an anonymous quote setter is alone at the inside, this position is a results of active quoting behavior in 63.87% of time. This level is quite the same for ECN which average 63,17% of active quoting. On the contrary, regular quotes average only 21.74% of active quoting, far less than the two other types of markets participants. Looking at differences in volume categories, we observe that the lower the volume traded, the lower the quote aggressiveness of quote setters when we consider market makers. This result holds whether we consider anonymous or non anonymous quoting. We see that the decrease is more pronounced for anonymous quote setter. An interesting feature is that high volume stocks experience a significant higher difference in active quote setting from anonymous quote setters with respect to ECNs. On the Ask side the difference averages 7 points and reaches 10 points on the bid side. We observe a reverse phenomenon for ECN quotes. They achieve best quotes more actively when trading activity decreases: they present an active quote rate of 67% when it reaches 61% for anonymous quote setter. We observe an increase in active quoting for all quote setters. It is more pronounced for anonymous quotes widening the observed difference with non anonymous quotes. In the post-trade anonymity regime, we see that anonymous quotes outpass ECNs for all volume categories. For low and medium categories we observe no significant changes, the anonymous quote setters are still the most active. We see however that for small volume stocks, we have a significant increase in active quoting: the increase averages 8 points on the ask side and 4 points in the bid side. This makes anonymous quote setters the most active market participant when they are alone at the inside.

These results, taken with those previously obtained, showing that anonymous quotes are alone at the inside only 8% of the trading day on average, demonstrates that anonymous quote setters are much less at the inside but when they reach the best quotes it is mainly due to active quoting.

Average best quotes improvement

In this part of the study we focus on the improvement that anonymous, regular and ECNs quote setters provide to the best quotes. To investigate this we compute the average dollar amount of

price improvement applied by each type of quote setter when they actively narrow the spread. The approach adopted here is different from the one proposed by Simaan et al.. Indeed, at the time of their study the minimum tick size was 1/16th of a dollar. Pursuing their anticompetitive practice argument, they expected the market makers orders represented via anonymous ECN quotes to exhibit a higher frequency of odd tick usage.[7] In accordance with what they predict, they find that the rate of odd tick quotations reached only 19% on regular market maker quotes. This is far less than the 49% observed when quotes were posted via ECNs. Since April 2001 and the introduction of decimalization, Nasdaq listed stocks are quoted with a tick size of only one cent. Various studies have shown that the decimalization has lead to a decrease in quoted spreads. For instance, Biais, Bisière and Spatt (2002) show that Island compete with market makers by frequently undercutting their best quotes at a one (small) Island tick level. Table 5 shows the average amounts of best quotes improvement when a quote setter actively narrows the spread. These amounts are expressed as a percentage of the prevailing quote midpoint. Contrary to Simaan et al., we did not find significant differences between quote setters. They present an average of 0.07% of best quotes improvement on both sides of the market. The introduction of post trade anonymity does not seem to significantly affect the conclusions exposed earlier. Though results are not reported here we also investigate the undercutting behaviour of various quote setters. Once again, we did not find significant different patterns.

Quoted depth

The last dimension of the first part of the study encompasses quoted depth. Barclay et al. (1999) argue that an improvement in quotes may be accompanied by a worsening in quoted depth. Here, we have conjectured that dealer may use anonymity to unwind large positions acquired during the trading day. To investigate this point we look at the percentage of time a quote setter exhibit a quoted depth higher than 100 shares. We take these 100 shares as a benchmark as it is the minimum level of shares that must be quoted by market makers to comply with its regulatory requirements.

If our predictions are correct, we would find a higher proportion of quoted depth higher than the 100 shares when an anonymous quote is alone at the inside. Results are presented in Table 6. We find that anonymous quotes exhibit the higher proportion as it reaches an average of 70% and 73% percent when they are respectively alone at the inside ask or bid. ECNs quoted depth greater than 100 shares averages 67% whereas the one quoted via regular market makers quotes reaches 62% at the ask side and 64% at the bid side.The panel B show a general drop in quoted

[7]The investigation of odd ticks quotation was first used by Christie and Schultz in their 1994 study. The lack of odd ticks quotations on Nasdaq market, before the implementation of the Order Handling Rules, allowed them to shed some light on collusion that reined at this time.

depth. However these changes are not statistically significant.

5. THE PRICE DISCOVERY PROCESS

The price discovery process is the process by which a market collects information about a security from market participants and incorporates that information into prices. The efficiency of the price discovery process is a fundamental issue for security markets. The more efficiently markets process information about trading interests, the more investors are encouraged to participate in security trading. This results in greater liquidity, more information and better price discovery. Each participant quote update reflects information but also noise caused by uninformed traders and microstructural effects as bid-ask bounce or inventory adjustments. The purpose of this section is to quantify the contribution to price discovery process by anonymously submitted orders. Are these orders informative or are they just adding noise? Foucault, Moinas and Thiessen (2004) have looked in this direction. Dividing each trading in 30 minutes intervals, they find that there is a positive relationship between the magnitude of price movement in a time interval and the spread in the previous interval. Moreover they find that the size of the spread contains information about future price volatility but that this informativeness is smaller after the switch to anonymity. Grammig et al.(2001) and Reiss, Werner (2004) get opposite results. The first find that the probability of informed trading is lower in the non anonymous environment. The latter conclude that informed traders prefer to disclose their identity.
To investigate more deeply this point, we apply a measure proposed by Hasbrouck (1995) and found in Huang (2002), Tuttle (2002), among others. This measure is built on the following intuition: though quotes from individual participants might diverge in the short run, in the long run these divergences should vanish. Indeed, posted prices refer to the same security and after having removed all transient effects, these prices must share the same random walk component (i.e. the unobservable efficient price). The market participant's information share is then given by the contribution of its innovation to the total innovation in the common efficient price. The rest of the section is organized as follows. First we detail the econometrics of cointegration and their link with the information share methodology. Then, we expose the obtained results.

Cointegration and Information share

Suppose that the (unobservable) efficient price m_t follows a random walk:

$$m_t = m_{t-1} + u_t \tag{1}$$

where $E(u_t) = 0, E(u_t^2) = \sigma_u^2, E(u_t u_s) = 0$ for $t \neq s$.
Let $P_{A,t}, P_{NA,t}, P_{ECN,t}$ be respectively the best quote (bid or ask) posted by anonymous, non

anonymous and ECN quote setters. These observed prices are equal to the efficient price plus a component s_t materializing the noise.

$$p_t = \begin{bmatrix} p_{A,t} \\ p_{NA,t} \\ p_{ECN,t} \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} m_t + \begin{bmatrix} s_{A,t} \\ s_{NA,t} \\ s_{ECN,t} \end{bmatrix} \tag{2}$$

Given that the noise should reflect transitory effects, it is necessarily covariance stationary that is : $E(s_t) = 0 \quad \forall t$ and $E(s_t s_{t-k})$ is only a function of k. This means that each price, reflecting the efficient price, should contain a random walk component which renders them non stationary. In other words, if they contain information, all prices should be integrated of order one or $I(1)$. Moreover, as stated before, these prices reflect the same underlying security, so we expect them to be related to one another: any two prices will not arbitrarily diverge over time. In econometrics terms this implies that prices should be cointegrated and contain a common random walk component. Prices are cointegrated if there exists a nonzero cointegrating vector b such that $b'p_t = e_t$ is stationary. The e_t term is interpreted as the deviation from long-run equilibrium.When et is stationary, pricing errors are corrected over time.

Following the Granger representation theorem, we know that cointegrated variables may be equivalently represented as a Vector Autoregressive model (VAR) in levels, a Vector Moving Average model (VMA) or an Error Correction Model (ECM). Using the duality between these representations, we can extract the informational content of each market participant's quote. Suppose that $p_t = \begin{pmatrix} p_{A,t} & p_{NA,t} & p_{ECN,t} \end{pmatrix}'$ is expressed as a VAR in levels :

$$p_t = \phi_0 + \phi_1 p_{t-1} + ... + \phi_q p_{t-q} + \epsilon_t \tag{3}$$

with $E(\epsilon_t) = 0$ and $E(\epsilon_t \epsilon_s) = \begin{cases} \Omega & \text{if} \quad s = t \\ 0 & \text{otherwise} \end{cases}$

As stated before, as prices are cointegrated, it admits the following ECM of order M representation:

$$\Delta p_t = A_1 \Delta p_{t-1} + A_2 \Delta p_{t-2} + ... + A_M \Delta p_{t-M} + \gamma b p_{t-1} \tag{4}$$

Where the A_i matrices contain the autoregressive coefficients, bp_{t-1} represent the stationary error correction terms and γ the adjustment coefficients.

Cointegration also implies that prices share a common stochastic trend (Stock and Watson 1988) and can be expressed as :

$$p_t = p_0 + \psi(1) \sum_{i=1}^{t} e_i + \psi^\star(L) e_t \tag{5}$$

p_0 is the initial price and $\psi^\star(L)e_t$ is a zero mean covariance stationary process. The term of interest in this equation is given by $\psi(1) \sum_{i=1}^{t} e_i$ which is the random walk component common

to all prices.
The matrix sum of the moving average coefficients $\psi(1) = I + \psi_1 + \psi_2 + \psi_3 + ...$ captures the permanent impact of new information on prices. Given that we have cointegrated series, the theory states that the rows of $\psi(1)$ must be identical. Let's denote this row by ψ. We can now extract the variance of the random walk component which is given by

$$\sigma_u^2 = \psi \Omega \psi' \tag{6}$$

The Hasbrouck(1995) information share contribution of market participant j $(j = A, NA, ECN)$ is then given by the share of the variance attributed to this market participant:

$$IS_j = \frac{\psi^2 \Omega_{j,j}}{\psi \Omega \psi'} \tag{7}$$

If the innovation covariance matrix is diagonal, then we can have a clean decomposition of the random walk component variance. However, it is often that innovations in prices for different market participants are correlated. Thus the covariance terms are difficulty attributed to either quote setter. Hasbrouck (1995) suggests the computation of a maximum and a minimum information share measure by rotating the innovation covariance matrix to maximize and minimize the explanatory power of each market participant quote using a Cholesky factorization. To implement our analysis of the information revealed via anonymous, non anonymous and ECNs quotes, we need first to test whether the series contain information (i.e. a random walk component). Moreover, a proper price discovery process requires quotes not only to contain information but also to reflect the common information of the underlying asset (i.e. to be cointegrated). Finally, the estimation of the ECM model and the computation of the information shares can be implemented. The methodology and the results are exposed in what follows.

Do prices follow a random walk process?

Prices are assumed to follow a random walk process. This is due to their informational content. Testing for this is equivalent to testing for a unit root process. To conduct our analysis, we performed an Augmented Dickey-Fuller test of unit root in which we estimate the following equation :

$$\Delta p_t = \alpha p_{t-1} + \sum_{i=2}^{q} \beta_i \Delta p_{t-i} + \eta_t \tag{8}$$

The null hypothesis states that prices do not contain a unit root that is $\alpha = 0$. If this hypothesis is not rejected we can assert that prices do contain information. The obtained results are presented in table 7. For brevity purpose, only tests for ask quotes are exposed but similar ones where

obtained when considering bid quotes. We determine the optimal lag length by minimization of the Akaike Information statistic. The results suggest that quotes submitted by anonymous, non anonymous and ECNs quote setters contain information. Indeed, the null hypothesis is never rejected in all cases even when we consider a 1% signification level. This is true for all stocks as well as for both periods.

Do prices reflect common information?

We examine the quotes emanating from three sources. If these quotes effectively reflect the common information of the underlying asset, we should have a total of two independent cointegrating vectors. Indeed, one common stochastic trend means two independent cointegration relations. The adopted approach is the one proposed by Johansen (1988). This approach consider the rank of the matrix of cointegrating vecors in equation (4). He provides the following statistic :

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} ln(1 - \hat{\lambda}_{r+1}) \tag{9}$$

This statistic tests the null hypothesis that the number of cointegrating vectors is equal to r against the alternative it is strictly greater than r. Table 8 shows the Johansen test results for the ask side.[8] For both panels, the null hypothesis of $r = 0$ and $r = 1$ cointegrating vectors are successively rejected.This is once again true for all stocks included in the study. On contrary, the null hypothesis $r = 2$ is not rejected. The test leads to the conclusion that the quotes from anonymous, non anonymous and ECNs quote setters are cointegrated and the order of cointegration is two, the maximal one as hypothesized before. They thus share one common underlying trend.

Information share estimation

As exposed in the methodological part, we need first to estimate the ECM equation. The estimation was conducted considering a one-second time resolution and a two-minute maximum lag for the VAR terms.[9] To estimate the model, more precision have to be given relative to the structure of b in equation(4). Indeed, at equilibrium, we expect differences between prices to

[8]Once again, the test was also conduct for best bid quotes but is not reported for brevity purpose

[9]As we have three market, this requires to estimate 9 coefficients per lag. As we choose a two-minute maximum lag, this leads to a total of 9*120=1180 coefficients per day. To restrict the set of coefficients to be estimated, we follow Hasbrouck (1995, 2003) methodology. We imposed a second-degree polynomial distributed lags on lags 1-10, lags 11-20, lags 21-30. We also impose coefficient to be constant over lag 31 to lag 60, lag 61 to lag 90 and lag 91 to lag 120.

vanish giving

$$p_A = p_{NA} = p_{ECN}$$

Thus at equilibrium relationship is given by $bp_{t-1} = 0$. This is equivalent to :

$$E(bp_{t-1}) = \begin{pmatrix} 1 & -1 & 0 \\ 1 & 0 & 1 \end{pmatrix} \begin{pmatrix} p_{A,t-1} \\ p_{NA,t-1} \\ p_{ECN,t-1} \end{pmatrix} = E \begin{pmatrix} p_{A,t-1} - p_{NA,t-1} \\ p_{A,t-1} - p_{ECN,t-1} \end{pmatrix} = 0$$

In practice, we should include transaction costs c_t. But making the assumption that they are stationary (i.e. $E(c_t) = c_t$), the bp_{t-1} can be centered by subtracting its sample mean. The system can then be easily estimated. The moving average contained in $\psi(1)$can be recovered and the information shares computed.

The resulsts are presented in table 9. The bounds represent each participant's daily average relative contribution to the variation in the innovation matrix Ω. For clarity, we summarized the results considering the volume categories. As previously demonstrated in the literature,[10] ECNs are major contributors to the price discovery process. Their upper bound information share (IS) averages 56%. The second information provider are "regular" market makers quotes with an average of 40%. When we turn to anonymously posted quotes, their information share fall to 19% on average. Thus, even though they are informative, their informational content is quite small with respect to other type of quotes. However, summing up anonymous and ECNs quotes' information shares, we can see that it dominates the IS of "regular quotes" corroborating Grammig et al. (2001) conclusion that informed agents favor an anonymous environment. The exposed results hold for the two sample period. Indeed, we find no significant changes in the informational contents after the implementation of post-trade anonymity.

A closer look at the results by volume category exhibits interesting patterns especially for non anonymous quotes. Indeed, their informational content averages 29% and the difference with the IS of non anonymous quotes is statistically non significant. As the volume traded decreases, this difference increases at the profit of non anonymous quotes. We find the same behavior for the IS of ECNs. The informational content of ECNs quotes decreases for low volume stocks and is even smaller than non anonymous ones for low volume ones.

6. CONCLUSION

The aim of this study was to shed some light on market making activity for Nasdaq listed stocks trading. We wanted more particularly to assess the importance given to the ability to post anonymously. Indeed, previous studies such as Simaan, Weaver and Whitcomb (2003), have shown

[10] see Huang (2002)and Tutle (2002) for example.

that ECNs have managed to capture a high proportion of market makers quoting activity by offering the ability to post quotes anonymously. They even conclude that *"making the level of pre-trade transparency on Nasdaq more opaque by allowing anonymous quotes could improve price competition and narrow spread further"*. We investigate this point by looking at market makers reaction and changes in quoting behavior following the introduction of an anonymity feature on Nasdaq new trading platform: SuperMontage. We find that market makers quotes posted anonymously are 8% of the time alone at the inside, that they reaches this "inside alone" by more actively reducing the best quotes than regular quotes and that the quoted depth they offer is more frequently higher than the 100 shares minimum required. Contrary to the Simaan et al. (2003), we did not find evidence that anonymous quotes improved more the best quotes. Their results show that when posting quotes via ECNs, market makers are alone at the inside 19% of time. This is much more than what we find in our study. Turning to the price discovery process, we find that anonymous quotes contain information. However, their informational content is quite small with respect to other type of quotes: their information share averages 19% when it reaches 40% for non anonymous quotes and 56% for non anonymous ones. The introduction of post trade anonymity do not bring significant changes. This thus suggest that anonymity is not the only answer to the lack of quote competition observe between market makers and that other practices such as internalization, preferencing or payment for order flow may play a non negligible role.

Table 1 - Descriptive Statistics

This table presents the daily average descriptive statistics.

	Overall		High volume		Medium volume		Low volume	
	sept-03	nov-03	sept-03	nov-03	sept-03	nov-03	sept-03	nov-03
Average trade price ($)	29.54	31.06	29.54	25.50	32.14	33.92	32.315	33.75
Daily trade size	536.62	534.17	798.98	773.09	453.72	447.95	357.15	381.485
Daily number of trades	6 512,00	5664.13	12309.924	10602.02	5283.93	4636.38	1942.95	1754.01
Total number of trades	4 884 202	4 248 101	3 077 481	2 650 505	1 320 983	1 159 094	485 738	438 502
Total number of share traded (millions)	335441.55	285190.86	256710.60	213600.83	60009.66	53660.48	18721.28	17929.55

Table 2 : Positon with respect to the best quotes

This table gives the time weighted presence at the best quotes by type of quote setter for each volume category.

Volume categories	Anonymous	Non Anonymous	diff	ECN	diff
		Panel A : September 2003			
Overall					
At inside Ask only	22,71	24,98	2,28	22,28	-0,42
At Inside bid only	23,19	27,80	4,61	21,88	-1,32
at both bid and ask	19,95	24,94	4,99	46,74	26,79
none	34,15	22,28	-11,87	9,11	-25,04
High volume					
At inside Ask only	23,26	23,62	0,36	16,42	-6,84
At Inside bid only	22,01	26,74	4,72	15,25	-6,76
at both bid and ask	38,02	35,59	-2,43	63,51	25,48
none	16,71	14,05	-2,65	4,82	-11,88
Medium volume					
At inside Ask only	24,73	26,31	1,58	23,73	-1,00
At Inside bid only	25,41	28,92	3,51	21,91	-3,50
at both bid and ask	14,33	19,79	5,46	46,08	31,75
none	35,52	24,97	-10,55	8,28	-27,24
Low volume					
At inside Ask only	20,13	25,02	4,89	26,05	5,92
At Inside bid only	22,16	27,74	5,59	21,47	-0,69
at both bid and ask	7,50	19,44	11,94	42,06	34,56
none	50,22	27,80	-22,42	10,42	-39,80
		Panel B : November 2003			
Overall					
At inside Ask only	22,78	24,48	1,70	22,28	-0,50
At Inside bid only	21,61	27,83	6,22	21,88	0,26
at both bid and ask	23,67	25,45	1,78	46,74	23,07
none	31,94	22,24	-9,70	9,11	-22,83
High volume					
At inside Ask only	22,39	23,16	0,77	17,09	-5,31
At Inside bid only	20,77	26,45	5,68	17,36	-3,41
at both bid and ask	41,86	36,57	-5,29	60,52	18,67
none	14,98	13,81	-1,17	5,03	-9,95
Medium volume					
At inside Ask only	25,43	25,69	0,26	24,80	-0,62
At Inside bid only	23,66	29,31	5,66	25,10	1,44
at both bid and ask	19,26	21,47	2,21	39,66	20,40
none	31,66	23,53	-8,13	10,44	-21,22
Low volume					
At inside Ask only	20,51	24,59	4,08	24,95	4,44
At Inside bid only	20,41	27,73	7,32	23,17	2,76
at both bid and ask	9,89	18,31	8,42	40,03	30,14
none	49,19	29,37	-19,82	11,85	-37,33

Table 3 : Percentage of "Alone at the inside" positions

This table gives the percentage of time a quote setter is alone at the inside by type of quote setter for each volume category.

Volume categories	Anonymous	Non Anonymous	diff	ECN	diff
Panel A : Septmber 2003					
Ask Side					
Overall	7,33	16,37	9,03	26,46	19,13
High volume	5,39	11,41	6,02	15,11	9,72
medium volume	8,58	18,14	9,55	27,12	18,54
low volume	8,03	19,55	11,52	37,16	29,13
Bid Side					
Overall	7,64	18,30	10,66	24,07	16,43
High volume	5,18	12,70	7,52	14,29	9,12
medium volume	8,41	19,68	11,27	24,93	16,52
low volume	9,32	22,50	13,18	32,98	23,66
Panel B : November 2003					
Ask Side					
Overall	9,91	16,69	6,77	23,90	13,99
High volume	6,80	11,41	4,61	13,51	6,71
medium volume	11,68	18,84	7,17	22,77	11,10
low volume	11,26	19,81	8,54	35,42	24,16
Bid Side					
Overall	9,13	18,03	8,90	22,39	13,26
High volume	5,95	12,22	6,27	13,06	7,11
medium volume	10,36	20,12	9,76	21,46	11,10
low volume	11,09	21,74	10,66	32,66	21,57

Table 4 : Active Best quotes reduction

This table presents the percentage of time an “alone at the inside” position resulted from an active quoting by type of quote setter for each volume category.

Volume categories	Anonymous	Non Anonymous	diff	ECN	diff
Panel A : September 2003					
Ask Side					
Overall	63,83	21,74	-42,08	63,17	-0,66
High volume	66,14	22,70	-43,44	58,49	-7,64
medium volume	64,29	21,93	-42,36	63,38	-0,91
low volume	61,05	20,60	-40,45	67,64	6,59
Bid Side					
Overall	61,40	19,91	-41,49	59,43	-1,97
High volume	64,82	20,86	-43,96	54,53	-10,29
medium volume	61,25	19,64	-41,62	59,67	-1,58
low volume	58,12	19,23	-38,89	64,09	5,97
Panel B : November 2003					
Ask Side					
Overall	67,66	23,01	-44,65	64,07	-3,59
High volume	65,10	24,15	-40,95	60,33	-4,77
medium volume	68,67	23,03	-45,64	65,13	-3,54
low volume	69,21	21,86	-47,36	66,74	-2,47
Bid Side					
Overall	64,22	19,60	-44,62	60,69	-3,53
High volume	63,97	19,53	-44,44	56,35	-7,62
medium volume	66,69	20,71	-45,98	62,81	-3,88
low volume	62,00	18,55	-43,46	62,93	0,92

Table 5 : Average amounts of best quotes improvement

This table presents the average amounts of best quotes improvement when a quote setter actively narrows the spread. These amounts are expressed as a percentage of the prevailing quote midpoint.

Volume categories	Anonymous	Non Anonymous	diff	ECN	diff
		Panel A : September 2003			
Ask Side					
Overall	0,0708	0,0713	0,000	0,0720	0,001
High volume	0,0893	0,0928	0,004	0,0901	0,001
medium volume	0,0562	0,0576	0,001	0,0574	0,001
low volume	0,0669	0,0634	-0,004	0,0684	0,001
Bid Side					
Overall	0,0719	0,0764	0,005	0,0684	-0,003
High volume	0,0894	0,0961	0,007	0,0890	0,000
medium volume	0,0558	0,0608	0,005	0,0543	-0,002
low volume	0,0704	0,0723	0,002	0,0619	-0,008
		Panel B : November 2003			
Ask Side					
Overall	0,0671	0,0665	-0,001	0,0704	0,003
High volume	0,0839	0,0823	-0,002	0,0853	0,001
medium volume	0,0520	0,0530	0,001	0,0552	0,003
low volume	0,0653	0,0646	-0,001	0,0707	0,005
Bid Side					
Overall	0,0681	0,0740	0,006	0,0657	-0,002
High volume	0,0842	0,0901	0,006	0,0837	-0,001
medium volume	0,0527	0,0593	0,007	0,0517	-0,001
low volume	0,0675	0,0728	0,005	0,0617	-0,006

Table 6 : Quoted depth

This table presents the average percentage of time a quote setter exhibit a quoted depth higher than 100 shares by quote setter and volume categories

Volume categories	Anonymous	Non Anonymous	diff	ECN	diff
Panel A : September 2003					
Ask Side					
Overall	70,98	62,47	-8,52	66,16	-4,83
High volume	82,14	74,10	-8,04	77,76	-4,38
medium volume	69,99	57,15	-12,84	64,64	-5,36
low volume	60,82	56,14	-4,67	56,07	-4,74
Bid Side					
Overall	73,90	64,19	-9,71	68,25	-5,65
High volume	82,90	76,30	-6,60	79,16	-3,74
medium volume	72,19	59,29	-12,90	67,19	-5,00
low volume	66,61	56,98	-9,63	58,39	-8,22
Panel B : November 2003					
Ask Side					
Overall	67,89	61,42	-6,47	64,82	-3,08
High volume	78,58	74,91	-3,67	76,14	-2,45
medium volume	68,78	55,63	-13,14	63,75	-5,02
low volume	56,32	53,71	-2,61	65,59	9,27
Bid Side					
Overall	69,73	64,12	-5,62	66,21	-3,52
High volume	77,81	76,56	-1,25	77,05	-0,76
medium volume	70,59	59,58	-11,01	65,59	-5,00
low volume	60,80	56,20	-4,59	56,00	-4,80

Table 7 : Tests of unit root

This table gives the results of the Augmented Dickey-Fuller unit root "t-tests" of Ask quotes by stock for each type of quote setter and by volume category

Panel A : September 2003

High volume				Medium volume				Low volume			
Stocks	Anonymous	Non Anonymous	ECN	Stocks	Anonymous	Non Anonymous	ECN	Stocks	Anonymous	Non Anonymous	ECN
ADCT	-0.60	-0.31	-0.70	AAPL	-0.22	-0.19	-0.19	APCC	-0.43	-0.11	-0.90
ALTR	-0.33	-1.51	-1.50	BBBY	-0.08	-0.21	-0.32	BMET	-0.19	-0.01	-0.21
AMAT	-0.22	-0.30	-0.20	CHKP	-0.18	0.09	-0.06	CHRW	-0.41	0.01	-0.56
AMGN	-0.15	-0.96	-0.93	COST	-0.01	0.06	0.02	CMVT	-0.29	0.77	0.56
AMZN	0.09	1.83	1.79	CTXS	0.02	0.44	0.39	CPWR	-1.07	-0.66	-0.57
BEAS	-0.23	-0.23	-0.43	DISH	-0.19	-0.06	-0.15	CTAS	-0.06	0.20	-0.01
BRCM	0.38	1.36	1.27	GENZ	-0.06	0.08	0.09	DLTR	-0.35	-0.75	-0.45
CIEN	-0.44	-0.62	-0.66	GILD	-0.27	-0.06	-0.10	FHCC	-0.06	0.44	-0.47
CSCO	-0.09	0.10	0.08	KLAC	-0.13	0.18	0.15	FISV	-0.32	0.55	0.13
DELL	0.19	0.35	0.29	LLTC	-0.12	0.32	0.30	HGSI	-0.26	-0.39	-0.62
EBAY	0.25	0.91	0.86	MCHP	-0.21	-0.45	-0.37	INTU	-0.04	0.04	-0.04
INTC	0.50	0.66	0.71	MERQ	-0.07	0.08	0.06	IVGN	-0.44	-0.38	-1.09
JDSU	-0.57	-0.60	-0.56	MLNM	0.01	0.63	0.48	LAMR	-1.14	-0.15	-0.19
JNPR	-0.06	0.54	0.40	MXIM	-0.02	0.02	0.00	LNCR	-0.35	-0.20	-0.81
MEDI	-0.19	-0.59	-0.51	NTAP	-0.14	0.29	0.13	MNST	-0.34	0.06	-0.38
MSFT	-0.17	-0.14	-0.16	NVLS	-0.33	-0.83	-1.02	MOLX	-0.14	-0.21	-0.29
NVDA	-0.35	-1.41	-1.24	PSFT	0.02	0.69	0.58	PAYX	-0.11	0.44	0.35
NXTL	0.19	0.59	0.56	QLGC	-0.21	-0.24	-0.27	PETM	-0.27	-0.39	-0.24
ORCL	-0.04	-0.04	-0.09	SANM	-0.10	0.28	-0.14	PTEN	-0.54	0.84	0.15
QCOM	-0.08	-0.18	-0.19	SBUX	0.11	0.63	0.54	ROST	-0.29	-0.36	0.09
RFMD	-0.36	0.03	-0.02	SPLS	0.06	0.50	0.34	SNPS	-0.73	-1.87	-1.86
SEBL	-0.12	0.73	0.59	SYMC	-0.07	0.67	0.42	SPOT	-0.24	1.30	-0.72
SUNW	-1.51	-1.50	-1.54	TLAB	-0.08	0.15	-0.01	SSCC	-0.33	-0.43	-0.72
XLNX	-0.19	-0.51	-0.48	VRSN	-0.39	-0.50	-1.01	TEVA	-0.13	-0.37	-0.35
YHOO	0.40	0.95	0.93	VRTS	-0.20	-0.06	-0.08	WFMI	-0.60	1.36	0.52

1% critical value :-2.58%
5% critical value :-1.958%
10% critical value :-1.62%

Panel B : November 2003

High volume				Medium volume				Low volume			
Stocks	Anonymous	Non Anonymous	ECN	Stocks	Anonymous	Non Anonymous	ECN	Stocks	Anonymous	Non Anonymous	ECN
ADCT	-1.11	-1.49	-1.45	AAPL	-0.29	-0.95	-0.89	APCC	-0.19	-0.63	-0.52
ALTR	0.08	0.28	0.25	BBBY	-0.16	-0.59	-0.53	BMET	-0.11	-0.22	-0.26
AMAT	-0.82	-1.16	-1.00	CHKP	-0.48	-1.22	-1.23	CHRW	-0.82	-0.40	-0.79
AMGN	-0.02	-0.08	-0.14	COST	-0.31	-0.26	-0.27	CMVT	-0.42	-0.49	-0.37
AMZN	-0.25	-1.07	-0.99	CTXS	-1.26	-2.03	-1.94	CPWR	-0.30	-0.39	-0.53
BEAS	-0.46	-1.16	-1.04	DISH	-0.28	-0.78	-0.67	CTAS	-0.06	0.08	0.05
BRCM	-0.22	-0.83	-0.81	GENZ	-0.22	-0.58	-0.57	DLTR	-0.38	-0.83	-0.72
CIEN	-0.36	-0.18	-0.08	GILD	-0.01	0.34	0.28	FHCC	-0.15	0.52	-0.15
CSCO	-0.48	-0.46	-0.44	KLAC	-0.21	-1.04	-0.95	FISV	-0.19	-0.41	-0.46
DELL	-0.35	-0.98	-0.96	LLTC	-0.30	-0.88	-0.80	HGSI	-0.36	-0.98	-0.80
EBAY	-0.51	-1.02	-0.96	MCHP	-0.18	-0.71	-0.59	INTU	-0.18	-0.63	-0.56
INTC	-1.11	-1.23	-1.29	MERQ	-0.31	-0.97	-0.93	IVGN	-0.11	-0.05	-0.29
JDSU	-0.74	-0.69	-0.74	MLNM	-0.29	-0.96	-0.87	LAMR	-0.68	-0.40	-0.51
JNPR	-0.24	-0.94	-0.91	MXIM	-0.28	-0.78	-0.72	LNCR	-0.27	-1.13	-0.62
MEDI	-0.29	-0.73	-0.63	NTAP	-0.38	-0.83	-0.57	MNST	-0.48	-0.04	-0.39
MSFT	-0.86	-0.89	-0.86	NVLS	-0.20	-0.66	-0.60	MOLX	-0.25	-1.22	-0.76
NVDA	-0.41	-0.94	-0.87	PSFT	-0.27	-0.91	-0.74	PAYX	-0.46	-1.32	-1.39
NXTL	-0.40	-0.66	-0.63	QLGC	-0.18	-0.86	-0.79	PETM	-0.19	0.80	0.37
ORCL	-0.66	-0.66	-0.69	SANM	-0.29	-0.40	-0.20	PTEN	-0.69	0.03	-0.28
QCOM	-0.45	-0.83	-0.70	SBUX	-0.28	-0.75	-0.67	ROST	-0.08	-0.13	-0.04
RFMD	-0.53	-1.01	-0.81	SPLS	-0.20	-0.66	-0.64	SNPS	-0.53	-0.17	-0.54
SEBL	-0.39	-0.72	-0.60	SYMC	-0.65	-1.07	-1.08	SPOT	-0.31	-0.36	-0.47
SUNW	0.01	0.05	0.04	TLAB	0.25	0.59	0.18	SSCC	-0.25	-0.60	-0.25
XLNX	0.03	0.36	0.37	VRSN	-0.36	-0.83	-0.70	TEVA	-0.14	-0.43	-0.43
YHOO	-0.51	-1.05	-0.97	VRTS	-0.33	-1.01	-0.91	WFMI	0.73	1.16	0.52

1% critical value :-2.58%
5% critical value :-1.958%
10% critical value :-1.62%

Table 8 : Johansen cointegration rank test

This table gives the results of the the Johansen trace test for cointegration rank of Ask quotes by stock for each type of quote setter and by volume category

Panel A : September 2003

High volume				Medium volume				Low volume			
Stocks	H_0 r=0, H_1r>0 [a]	H_0 r=1, H_1r>1 [b]	H_0 r=2, H_1r>2 [c]	Stocks	H_0 r=0, H_1r>0 [a]	H_0 r=1, H_1r>1 [b]	H_0 r=2, H_1r>2 [c]	Stocks	H_0 r=0, H_1r>0 [a]	H_0 r=1, H_1r>1 [b]	H_0 r=2, H_1r>2 [c]
ADCT	1281.7418	448.9755	0.1764	AAPL	915.1944	291.2015	0.1284	APCC	724.9471	302.1519	0.4876
ALTR	806.9935	323.3247	2.7668	BBBY	799.6759	372.8255	0.0930	BMET	918.3579	290.6889	0.0120
AMAT	1153.5951	564.7897	0.1138	CHKP	869.7527	366.2472	0.0131	CHRW	567.6825	248.5176	0.1016
AMGN	854.6414	346.2501	0.7243	COST	913.3152	389.1394	0.0182	CMVT	740.9186	296.8883	0.3378
AMZN	875.0222	318.4990	3.3385	CTXS	976.0804	420.7181	0.1717	CPWR	780.8366	276.8136	0.3145
BEAS	783.5463	330.5632	0.3203	DISH	761.2967	316.6398	0.0314	CTAS	725.6396	331.5071	0.0227
BRCM	1067.1070	474.8394	1.3540	GENZ	900.1346	393.6896	0.0040	DLTR	820.3418	385.8537	0.5169
CIEN	797.1753	293.4982	0.3836	GILD	588.7949	273.5676	0.0068	FHCC	795.2068	297.8924	0.1742
CSCO	1226.1569	567.3763	0.0002	KLAC	948.7674	365.4081	0.0100	FISV	773.4861	322.4555	0.0035
DELL	976.6655	451.7397	0.1011	LLTC	1070.6285	471.9734	0.0777	HGSI	678.7305	83.4112	0.4187
EBAY	989.7657	336.8716	0.9419	MCHP	970.8339	443.0764	0.2872	INTU	799.1438	369.6201	0.0295
INTC	949.4009	429.9984	0.2901	MERQ	919.4802	420.9629	0.0037	IVGN	809.6428	297.7503	0.1756
JDSU	1185.8071	483.7717	0.5954	MLNM	861.1537	367.1940	0.2981	LAMR	742.1936	318.9944	0.0835
JNPR	910.2882	415.0921	0.1851	MXIM	1008.9470	479.4405	0.0050	LNCR	1009.7507	320.9711	0.0686
MEDI	809.2768	357.5064	0.5547	NTAP	1121.9092	384.4177	0.0486	MNST	734.9294	308.3262	0.0024
MSFT	1177.3871	529.4486	0.0537	NVLS	1081.9553	484.9530	0.1613	MOLX	827.5178	327.8111	0.0076
NVDA	680.9136	260.9803	2.3314	PSFT	617.8347	211.2532	0.3123	PAYX	920.3816	379.6633	0.0779
NXTL	834.0503	323.7530	0.2881	QLGC	1012.7645	453.4799	0.0701	PETM	933.5914	336.6614	0.3198
ORCL	1172.7481	504.2008	0.0013	SANM	871.7320	312.1044	0.0806	PTEN	531.2918	233.6124	0.6126
QCOM	879.9973	384.5352	0.0927	SBUX	1112.1976	391.9537	0.2304	ROST	697.4332	265.5802	0.1207
RFMD	805.9216	229.0802	0.0093	SPLS	818.1426	287.7693	0.0573	SNPS	673.7226	311.6086	3.1236
SEBL	1099.3786	493.0080	0.5982	SYMC	698.4584	244.6990	0.3582	SPOT	998.4745	455.5982	0.0172
SUNW	1297.2310	563.5477	1.2979	TLAB	785.7074	251.4904	0.0015	SSCC	839.5406	345.1706	1.6865
XLNX	1128.5477	537.6602	0.3059	VRSN	774.8964	289.3623	0.8255	TEVA	603.3882	267.4857	0.1647
YHOO	875.3489	332.2769	0.7291	VRTS	995.4608	429.1429	0.0262	WFMI	674.0141	262.6382	0.8912

[a] 5% critical value : 24.08

[b] 5% critical value : 12.21

[c] 5% critical value : 4.14

Panel B : November 2003

High volume				Medium volume				Low volume			
Stocks	H_0 r=0, H_1r>0 [a]	H_0 r=1, H_1r>1 [b]	H_0 r=2, H_1r>2 [c]	Stocks	H_0 r=0, H_1r>0 [a]	H_0 r=1, H_1r>1 [b]	H_0 r=2, H_1r>2 [c]	Stocks	H_0 r=0, H_1r>0 [a]	H_0 r=1, H_1r>1 [b]	H_0 r=2, H_1r>2 [c]
ADCT	938.7839	407.8218	1.8586	AAPL	902.4608	417.9762	1.8790	APCC	658.0476	296.3821	0.3123
ALTR	890.4897	390.0788	0.7784	BBBY	908.6696	405.9906	0.5888	BMET	932.8552	294.6654	0.0029
AMAT	1142.8023	520.2493	1.9846	CHKP	864.6115	390.5450	0.6107	CHRW	1169.7326	453.9981	0.5920
AMGN	1068.2933	481.1356	0.0127	COST	1243.8475	464.4091	0.0520	CMVT	893.4903	394.9106	0.3174
AMZN	813.7357	314.0889	2.1487	CTXS	875.4409	422.3822	3.5640	CPWR	959.9465	276.1477	0.1104
BEAS	745.6614	259.5213	1.9814	DISH	499.4500	90.5988	0.7615	CTAS	770.9947	363.0047	0.0849
BRCM	871.2904	356.5181	0.4349	GENZ	980.8047	448.9478	0.1581	DLTR	707.6980	338.5377	0.4655
CIEN	861.8020	386.8733	0.0761	GILD	791.4770	268.8464	1.0925	FHCC	640.0846	260.3782	0.2171
CSCO	1256.2405	574.7276	0.0533	KLAC	883.6614	378.0042	2.1610	FISV	781.5903	334.3705	0.4096
DELL	872.4626	350.5624	0.5043	LLTC	961.7838	462.4400	1.0698	HGSI	749.2185	347.6100	3.4444
EBAY	1242.8100	523.1640	1.5012	MCHP	1061.9313	356.9097	0.5402	INTU	600.5648	242.6518	0.0528
INTC	1091.3613	479.5210	1.2757	MERQ	683.9053	202.9149	1.8978	IVGN	606.1112	261.2497	0.0005
JDSU	1112.2298	465.0691	0.5921	MLNM	917.0127	356.7229	1.4836	LAMR	747.5445	221.6015	0.2825
JNPR	964.9054	440.7986	1.0305	MXIM	1048.0469	489.1505	0.1361	LNCR	588.4651	258.3333	2.4439
MEDI	742.3971	317.1002	0.6963	NTAP	572.6465	155.4972	1.3739	MNST	657.0086	236.9828	2.3231
MSFT	1195.7094	582.1899	1.0477	NVLS	1019.3337	449.6840	0.2100	MOLX	817.2668	382.1351	0.7076
NVDA	730.5059	345.1891	1.6820	PSFT	580.6055	145.0796	1.1695	PAYX	934.4299	365.9085	0.6628
NXTL	762.3856	330.0198	0.3615	QLGC	1085.0316	520.9733	0.8403	PETM	570.3166	203.8357	0.0353
ORCL	1138.2020	533.4509	0.4822	SANM	1021.8107	428.6599	0.0884	PTEN	711.6518	305.0962	0.2974
QCOM	1053.7562	458.3437	1.6774	SBUX	806.8153	286.7854	1.3049	ROST	410.9792	54.8399	0.0028
RFMD	978.5209	416.2309	1.6941	SPLS	579.4263	142.7519	0.5436	SNPS	789.7611	305.6607	0.8107
SEBL	975.2652	478.3713	0.9296	SYMC	667.5062	307.1363	1.6110	SPOT	1022.6380	312.1339	0.3785
SUNW	1216.0275	548.5661	0.0024	TLAB	858.8542	303.6773	0.0901	SSCC	420.6883	45.7172	0.6097
XLNX	863.6861	404.3269	0.7064	VRSN	759.4339	303.6014	1.3557	TEVA	699.1357	312.8752	0.9381
YHOO	1000.2553	430.0774	0.7922	VRTS	752.1517	289.1814	2.2258	WFMI	707.2664	289.0685	0.5364

[a] 5% critical value : 24.08

[b] 5% critical value : 12.21

[c] 5% critical value : 4.14

Table 9: Information Shares

This table presents the average upper and lower bound information shares by volume category. The results are presented for both ask and bid quotes

Panel A : Ask Quotes

	September 2003						November 2003					
	Upper bond			lower bond			Upper bond			lower bond		
	Anonymous	Non Anonymous	ECN	Anonymous	Non Anonymous	ECN	Anonymous	Non Anonymous	ECN	Anonymous	Non Anonymous	ECN
overall												
mean	18.99%	40.41%	55.75%	11.98%	31.18%	42.80%	18.98%	42.62%	53.81%	11.53%	33.42%	40.82%
median	12.87%	37.32%	58.23%	8.60%	26.90%	43.87%	11.59%	39.36%	57.25%	6.947%	28.71%	41.57%
standard deviation	0.191	0.197	0.214	0.124	0.211	0.201	0.207	0.209	0.222	0.126	0.223	0.210
High volume												
mean	28.64%	32.73%	62.80%	15.22%	20.16%	42.99%	31.18%	33.98%	60.99%	15.68%	21.23%	39.81%
median	18.71%	29.17%	67.04%	10.30%	15.45%	44.34%	24.18%	30.44%	63.03%	11.72%	17.61%	39.93%
standard deviation	0.267	0.158	0.186	0.160	0.162	0.202	0.275	0.180	0.194	0.149	0.177	0.214
Medium volume												
mean	15.59%	37.09%	60.21%	10.78%	28.27%	48.58%	13.08%	40.91%	58.52%	9.14%	31.51%	47.32%
median	13.39%	35.40%	61.38%	9.32%	25.93%	48.13%	9.26%	38.79%	60.77%	4.99%	28.58%	48.00%
standard deviation	0.115	0.166	0.178	0.092	0.160	0.174	0.124	0.178	0.202	0.104	0.173	0.195
Low volume												
mean	12.63%	52.02%	43.52%	9.90%	45.84%	36.32%	12.71%	53.46%	41.23%	9.83%	48.18%	34.80%
median	9.92%	49.39%	45.30%	6.58%	41.05%	36.7%	9.35%	50.82%	42.14%	6.58%	43.86%	34.45%
standard deviation	0.115	0.213	0.224	0.103	0.223	0.208	0.123	0.222	0.218	0.108	0.230	0.203

Panel B : Bid Quotes

	September 2003						November 2003					
	Upper bond			lower bond			Upper bond			lower bond		
	Anonymous	Non Anonymous	ECN	Anonymous	Non Anonymous	ECN	Anonymous	Non Anonymous	ECN	Anonymous	Non Anonymous	ECN
overall												
mean	20.30%	42.97%	51.26%	13.16%	34.13%	39.23%	19.01%	43.31%	52.47%	12.02%	34.11%	40.13%
median	14.12%	40.50%	54.63%	8.64%	30.53%	39.86%	12.64%	41.58%	54.73%	7.72%	30.68%	40.52%
standard deviation	0.195	0.202	0.224	0.135	0.214	0.202	0.199	0.196	0.211	0.128	0.208	0.202
High volume												
mean	28.49%	35.56%	59.01%	15.50%	23.35%	40.41%	29.61%	35.80%	58.47%	15.98%	23.16%	39.41%
median	19.42%	32.61%	61.14%	11.15%	19.64%	39.71%	19.21%	33.52%	59.23%	10.77%	19.59%	37.66%
standard deviation	0.244	0.176	0.190	0.149	0.177	0.193	0.266	0.166	0.188	0.159	0.162	0.209
Medium volume												
mean	15.09%	41.82%	55.37%	10.41%	33.37%	44.44%	13.72%	43.25%	55.83%	9.44%	33.81%	44.46%
median	11.96%	39.58%	58.91%	7.92%	31.54%	46.39%	11.85%	42.50%	57.19%	6.88%	32.59%	44.61%
standard deviation	0.120	0.184	0.193	0.095	0.181	0.181	0.117	0.173	0.183	0.094	0.169	0.175
Low volume												
mean	17.04%	52.27%	38.36%	13.60%	46.68%	32.29%	13.70%	51.22%	42.55%	10.70%	45.87%	36.18%
median	12.01%	50.14%	38.44%	8.22%	43.51%	30.58%	9.28%	50.58%	42.97%	6.52%	43.12%	36.36%
standard deviation	0.169	0.210	0.235	0.152	0.218	0.215	0.133	0.218	0.227	0.121	0.225	0.212