Hidden Orders, Trading Costs and Information

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Abstract

This paper explores the use of non-displayed (reserve) depth in Nasdaq market-maker quotes in SuperSOES. Non-displayed size represents 25 percent of the dollar-depth at the NBBO in the Nasdaq 100; this appears to be additional depth provided to the market, rather than a shift away from displayed depth to non-displayed depth. Market participants tend to use reserve size more for firms with high idiosyncratic risk and high volatility. While the presence of hidden depth at the inside has no effect on effective half-spreads, the information content of a trade (as measured by the midquote adjustment in the 30 minutes post-trade) is significantly lower when reserve size is quoted, suggesting reserve size is a signal of short-term price movements. Although this information impact is present at thirty second and five minute intervals post-trade for many classes of market participants, the presence of non-displayed depth by investment banks and wirehouses is predictive of price changes up to 30 minutes post-trade. Displayed depth does not predict daily returns, but the reserve size quotes of investment banks and wirehouses is indicative of which stocks will increase or decrease in price over the course of the day's trading. This effect is strongest at earnings releases, where only investment bank and wirehouse non-displayed depth predicts returns of individual stocks in the wake of an earnings announcement.

There is a rich literature exploring the relationship between market transparency and market quality. The SEC has stated that market transparency is fundamental to market fairness and efficiency (SEC, 2000); yet, it is unclear that complete transparency provides best execution and depth, as demonstrated by the natural experiment afforded by the Toronto Stock Exchange's switch to an open limit order book, which did not increase depth and actually increased spreads and volatility in the market (Anaad and Weaver, 2006). Although the Nasdaq market moved toward greater transparency with the revision of Order Handling Rules in 1997, the introduction of SuperSOES in 2000 gave market makers the ability to post additional depth with their quotes that is auto-executable, yet not visible to the market as a whole. This paper is the first to describe how Nasdaq market participants use this feature and measure its impact on market quality.

Why would a market participant wish to hide depth? One reason might be to mitigate the adverse selection costs of the option that a market participant writes when he posts a quote. Nasdaq market makers are required to maintain two-sided quotes during market hours, and to trade up to their quoted size when presented with a willing counterparty. Quotes thus have an option value, and under some circumstances the adverse selection costs market participants face may be mitigated by hiding size (this will be discussed further in the next section.) A second reason for market participants to hide size may be to conceal information. Although many early market models began with the assumption that liquidity providers were uninformed and traded with liquidity demanders who might be informed, this is surely an oversimplification. A trader may acquire or unwind a position for informational reasons or otherwise via different routes, depending on his desire for immediacy and price certainty. He may submit a market order to demand liquidity, or submit a limit order and attempt to trade as a liquidity provider who earns rather than pays the spread. He may also do so at different levels of anonymity – using his quote in the Nasdaq montage or an anonymous ECN order. The ability to use hidden size within SuperSOES is a vehicle to trade as a liquidity provider with some anonymity, albeit less than provided by an ECN. The anonymity in ECNs does have a cost, however – the existence of substantial size quoted in an ECN is usually visible to the market as a whole[2], and is known to be informative of short-term market movements (Huang, 2002.) Furthermore, ECN quotes in SuperSOES are not autoexecutable: to trade with the liquidity in ECNs requires special routing of the order. Thus to some extent, the liquidity in ECNs is less accessible to the market as a whole.

Although using the hidden size feature of SuperSOES avoids the fragmented markets problem that may affect ECN orders, the market participant does sacrifice some execution priority in doing so. In the case when multiple market participants share the inside, a market order that executes against their quotes will first exhaust all displayed depth at the best quote. Any remaining portion of the market order (that would now "walk the book" in a market with no hidden size feature) will execute against nondisplayed depth in the market maker's quotes. Once the market order execution is complete, if there is additional hidden depth in a quote, it will replenish the displayed size and the market participant will have time-priority (for the displayed size) for execution in preference to any market participant who posts a new quote at the inside.

In this paper, I describe the use of hidden depth in the Nasdaq market and measure how it impacts the informational efficiency, overall liquidity and trading costs in the market. I show that hidden liquidity accounts for 25 percent of the inside depth in Nasdaq 100 stocks; overall dollar depth in the Nasdaq market has increased 57 percent with the SuperSOES introduction (during a period when matched NYSE firms showed a decrease in displayed liquidity). The hidden depth feature is more likely to be used in stocks with a high probability of informational events, supporting the idea of hidden orders as a vehicle for the mitigation of adverse selection costs to liquidity providers. The use of hidden size has no significant effect on effective half-spreads incurred by

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[2] Some ECNs do allow for hidden size in their orders that is not displayed to the market as a whole.

trades; however, while displayed size conveys little information about future price movements, hidden size is predictive of future market price movements – more so when used by investment banks and wirehouses.

A. Literature Review

There is a growing body of literature that examines the relationship between pre-trade transparency and measures of market quality. Many of these models begin with the classic problem of an uninformed market-maker faced with a potentially informed trader, recognizing that a quote is a free option which can be exercised profitably by an informed trader (Copeland and Galai, 1983). In a more complex market that allows traders to provide or demand liquidity, the trader must balance the execution certainty of a market order versus the control of execution price afforded by limit orders (Cohen et. al. 1981, Handa and Schwartz 1996). The interaction of these two forces – the adverse selection costs borne by liquidity providers and the desire for immediacy of execution at low cost by traders – has borne a rich set of models of the trading process and the intricacies of market design.

Numerous studies and theoretical models consider the effects of pre-trade transparency (price quotes, participant identities, or market clearing prices) on market quality characteristics. Handa and Schwartz (1996) describe a security trading market in terms of a balance of the supply of liquidity (limit orders) and demand for liquidity (market orders); the authors conjecture that reducing transparency increases a liquidity provider's adverse selection costs and may actually decrease liquidity. Foucault, Moinas and Theissen (2006) provide evidence that liquidity providers increase market liquidity when they can quote anonymously. Other studies predict that market quality (as measured by spreads, liquidity and volatility) improves with transparency (Flood et. Al. 1999, Harris 1996 among others); however this result is not always supported empirically. Anaad and Weaver (2006) describe the natural experiment afforded by the Toronto Stock Exchange's switch to an open limit-order book format; they report an increase in spreads and volatility which was accompanied by a decrease of depth in the wake of the market structure change. Boehmer, Saar, and Yu (2005) examine the NYSE's introduction of OpenBook in 2002, which allowed market participants to observe limit orders (a move toward increased pre-trade transparency); they document an increase in overall liquidity and decreased execution costs. Pardo and Pascual (2005) examine hidden limit orders from the Spanish Stock Exchange; they find evidence that limit order traders are motivated by liquidity needs rather than information.

Both Bloomfield and O'Hara (1999) and Flood, Huisman, Koedijk and Mahieu (1999) examine transparency in an experimental market economy. While Bloomfield and O'Hara show that both trade disclosure and pre-trade transparency of quotations increase informational efficiency while widening spreads, Flood et al. report a contrary result where opaque markets are more efficient and have higher spreads.

II. Motivation and Data Description

A. Motivation

There are several models suggesting testable hypotheses regarding the usage and effect of hidden depth. Foucault and Sandas (2002) present a model in which a risky security is traded in a market with discrete prices and a time-priority rule for execution, similar to the models of Glosten(1994), Sandas (2001) and Seppi (1997). Risk neutral traders arrive sequentially and can place a single limit order with both visible and hidden depth. Noise traders place market orders which execute against the aggregate book using both time priority and displayed depth priority (all displayed depth at a given tick is exhausted before hidden depth is filled). Later, an information event may happen, in which case informed traders arrive instantaneously and place a market order which executes against the liquidity providers' aggregate book.

If a news event occurs, an informed trader arrives at the market. He would like to buy an infinite number of shares at the best offer, but can only trade up to the depth in the book. The informed trader must decide how many shares he wishes to buy with a market order (the model disallows use of marketable limit orders[3]); if the quantity of his market order exceeds the depth at the best price, he must purchase or sell shares at an inferior price. His criterion function in deciding how many shares to purchase considers the equally weighted average price per share. Because he does not know how many total shares are available at ticks with stale prices (where he can profitably trade), he submits an order for fewer shares than he would if he could see the hidden depth in the book (considering the possibility that he may be purchasing (selling) some of those shares for a price that exceeds (is less than) the current security value.) In this manner, the liquidity providers reduce their adverse selection costs, since they are less likely to trade with an informed counterparty in the wake of an informational event.

Foucault and Sandas describe an equilibrium in which the displayed depth in the book is the same whether hidden orders are allowed or disallowed; any hidden depth in the book is additional liquidity provided to the market because of the allowance of hidden orders. There is always a strictly positive probability of hidden depth in the book, and the size of hidden orders (relative to displayed orders) increases with the probability of a news event.

Esser and Mönch (2005) present a second model in which a trader wishes to liquidate a large stock position. The trader is allowed to submit a limit order and reveal only part of the total order size to the market. The execution rules in this market are akin to those observed in practice: the initial visible depth has time priority over orders which are placed at the same price at a later time. When the visible depth is exhausted, the visible is size is replenished from the hidden depth. This newly visible portion is assigned a time priority which places it behind all depth which was visible at the same price when the replenishment was triggered. The other side of the book (the bid side when we are modeling a stock sale) is modeled as a stochastic price series with a constant number of shares (bid size is constant); the path the price process for the stock follows is a function of both the displayed order imbalance (more visible shares on the offer side causes downward price pressure) and has a stochastic trend.

Esser and Mönch's model captures several important characteristics of orders with hidden size. First, given the stochastic nature of the price process, the time to complete execution of an order with a hidden size component decreases with the proportion of size displayed. Simply speaking, as the proportion of the order that is hidden increases, the limit price of the order must be hit more times in order to achieve full execution. Second, the model recognizes that the display of size itself contributes to the price process through the order imbalance effect. Consequently, there is a countervailing effect where complete display of the order's size would make it less likely that the limit price would be met as the price process develops. The model thus captures the tension between a trader's desire for quick execution and his desire not to allow his own trading to adversely affect the price process. The authors show that when the proportion of the displayed order size increases, the drift of the stochastic price process away from the order increases, while the number of times the price limit must be hit decreases.

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[3] See F&S for a discussion of the restrictiveness of this assumption. In a market in which there is no cost to placing a marketable limit order, traders would not use hidden size in equilibrium. However, execution priority rules may impose an opportunity cost on these orders, still allowing for the use of hidden size in equilibrium.

Rindi (2002) presents a third model of pre-trade transparency based on the models of Grossman and Stiglitz (1980) and Kyle (1989). The model features two groups of risk-averse agents, some of whom may be informed insiders; these agents submit limit orders to hedge their endowment of risky assets and possibly to speculate on information. Uninformed traders observe the book and try to infer the information contained in informed traders' orders. Noise traders submit a randomly determined market order against the aggregate limit order book.

Rindi characterizes the equilibrium in this model under three regimes of transparency. In the low-transparency setting, only market clearing prices are observed. In the medium transparency setting, limit and market orders are observable, but the identity of traders is not. In the full transparency setting, both orders and trader identities are observed.

In characterizing the equilibria in these three transparency regimes, Rindi shows that when information acquisition is endogenous, enhanced transparency can actually reduce market liquidity, unlike in previous models in which the uninformed increase the liquidity they provide when transparency is high. Because the uninformed traders can infer the informed traders' information by observing the book, they trade as if they were informed. Anticipating this, traders are unwilling to invest in information acquisition activities; fewer informed traders are willing to enter the market, and the equilibrium liquidity in the fully transparent market is lower than that in less transparent setting.

Together, these three models suggest several testable hypotheses regarding the effect of the hidden depth provision of SuperSOES upon the Nasdaq market:

Hypothesis 1: *Liquidity providers will commit to trade more shares if they are not obligated to reveal the complete size of their order.* Foucault and Sandas's model suggests that uncertainty about depth at the inside reduces the size of informed market orders; this mitigates the adverse selection costs of liquidity providers and liquidity to the aggregate market increases.

Hypothesis 2: *Liquidity providers will hide more depth in securities with a high probability of information events.* As the probability of an information event increases, the probability of trading against an informed counterparty increases. Consequently, the costs of adverse selection are highest in these securities and liquidity providers will hide more depth to reduce those costs.

Hypothesis 3: *Liquidity providers will hide more depth in securities with greater volatility.* When an order has a hidden component, each time the displayed depth is refreshed the order's time priority is reset. Consequently, the price process must hit the price limit more times before the hidden depth is exhausted. The delay until execution will decrease with price volatility.

Hypothesis 4: *Market participants whose quotes contribute the greatest information to the market are more likely to use hidden size.* Because their quotes have a greater signaling effect than other market participants, these market makers will use reserve size more to reduce free-rider costs of displaying size. Huang (2002) studies the price discovery process between ECNs and Nasdaq market makers; he demonstrates that the published quotes of ECNs (followed by the quotes of wirehouses) are in aggregate more informative than those of wholesalers and institutional brokers. This suggests that among Nasdaq market participants, wirehouses should utilize the reserve-size feature more than other market participants.

Hypothesis 5: *The information impact of an order decreases when a greater proportion of order size is hidden.* The model of Esser and Mönch predicts that the stochastic price process will drift downward when a large sell order appears in the book. This effect is mitigated by hiding some of the order size. Empirically, we should expect to see less downward (upward) drift in price in the wake of a trade when the aggregate size of sell (buy) orders exceeds the aggregate size on the opposite side of the limit order book.

B. Description of Data

The dataset consists of all Nasdaq National Market quotes submitted during three sample weeks: June 11-15, 2001 (before SuperSOES implementation, when the reserve size feature was not available); April 22-26, 2002 (the primary sample week); April 15-19, 2002 (used to construct lagged variables when needed); and July 22-26, 2002 (a later sample used for robustness checks of results.) The quotations are used to construct a displayed/hidden liquidity schedule throughout the week that is akin to a limit order book. Quotes which have a "closed" flag for the market maker are excluded, except where those quotes automatically become "open" at start of day if not updated. ECNs and regional exchanges are included in the book.

In order to eliminate stale quotes that may be associated with a market maker who is closed system-wide but still has a quote reported, any quote which would improve the NBBO is disregarded[4]. Where trading volume is used, it consists of media reported trades that are not flagged as cancelled. "As of" trades (generally trades pre-open that are reported the next day) are included in trading volume. Where trades must be classified as buys or sells, the Lee-Ready (1991) algorithm is used.

[4] My data includes both the quotes of all market participants, and a record of the NBBO at every point in time. The quotes that are disregarded are those that would improve the NBBO as reported by Nasdaq.

Shares outstanding data for both Nasdaq and NYSE issues is from CRSP, and is as-of December 31, 2001[5]. NYSE specialist quotes are taken from TAQ. Closing prices for the eight-month time series of NNM stocks is taken from Yahoo! Finance, which receives quote date from Reuters.

Where market participants are classified into groups (wire houses, investment banks, regional brokers, wholesalers, ECNs, and other), the classification system used was developed by Nasdaq Economic Research and used in Huang (2002).

Although the dataset is extensive in its detail, it is important to note its shortcomings. Although hidden depth is reported for market makers, the complement to this – hidden depth on ECNs – is missing from the dataset. In practice, a market maker's quote may serve to conceal – not signal – his trading strategy; his presence on the bid side of the inside market may be concurrent with a large sell order placed on an ECN. Some ECNs – particularly Island, which is a substantial contributor to the inside market in my sample – allow hidden depth in a displayed limit order. On the other hand, most of this depth is not auto-executable[6], making it less accessible to a market order submitter, unless he subscribes to the ECN or actively manages the routing of the order. Because of this, and also because market participants may choose to manually refresh their quotes as they observe trades or to offer depth improvement to their quotes, the non-displayed depth of the market is certainly understated.

Table I presents summary statistics on number of market makers, market capitalization, price and percent volatility for stocks in my sample, during both the 2001 and 2002 sample period. There are 97 Nasdaq 100 stocks in the sample: one stock was dropped due to a ticker symbol change during the April 2002 sample period (Adelphia Communications Corporation went OTC the

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[5] TSO data is used for market capitalization measures used to construct matching samples.

following month); market capitalization data was missing for two others (Check Point Software Tech, and Flextronics International Ltd.). The median stock is quoted by 67 market participants, has share price of $37.45, and has market capitalization of just over $8 billion in June, 2001; in April, 2002, the median stock has 78 market makers, share price of $26.78, and market capitalization of just over $11 billion[7].

When comparing two periods in time, one faces the problem of choosing appropriate sample periods that are comparable to each other, and representative of the market as a whole. The share price change from 2001 to 2002 highlights the down market experienced between the 2001 and 2002 sample periods (during the time that SuperSOES was implemented); some discussion of the market during the sample weeks is thus in order. When comparing two weeks in Nasdaq, finding "typical" weeks for comparison is problematic. Considering the time between decimalization and SuperSOES implementation, there are weeks of large absolute returns, and weeks that fall during earnings season. Figure 2 presents QQQ prices from March through May of 2002; the sample week selected has a cumulative return of –7.6%, and is not atypical for the second-quarter of 2002 in return magnitude. The June, 2001 week was chosen to have a comparable return (-7.5%); the weekly QQQ prices from May through July of 2001 are presented in Figure 1. Both of the sample weeks are very bad weeks for the market, but avoid periods of earnings announcements, which are likely to be "news" periods for individual securities. The activity in the wider market may affect market characteristics as a whole, but by avoiding periods of anticipated news (earnings announcements in particular), I minimize the impact of security-specific events upon differences between the two sample periods. Finally, I use a seven-month time series of daily reserve-size use by market-participants from January to July of 2002 to check robustness of my results and examine the use of reserve size around earnings announcements.

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[6] One ECN in the sample is auto-executable and does report reserve size.

Before moving to discussion of results, some discussion on the reserve size data itself is in order, since this data has not been described in the literature. Table II presents statistics on displayed and total quoted dollar depth (including reserve depth) during the 2001 and 2002 sample periods. The depth is reported as time-weighted dollar depth and is equally weighted across all stocks in the sample. Dollar depth is aggregated at the inside market and the next five once-cent ticks on each side, the minimum tick size for quoting during both pre- and post- sample periods. The average dollar depth at the inside bid is $45,252 during the 2001 week; the displayed depth at the best bid is $50,374 in the post- sample. When reserve (non-displayed) depth is included, the depth at the bid in the post-sample is $66,661, a 47% increase from 2001. Although the depth increase at the NBBO is substantial, it is even higher at ticks away from the inside. The market appears deeper on the bid side, but disproportionate depth is non-displayed on the ask side – likely due to the down-market during the sample weeks. The magnitude of non-displayed depth is significant: at the inside market (best bid and ask), non-displayed depth represents 25% of the dollar depth in the NNM[8].

The use of the reserve-size feature of SuperSOES varies by market-participant type, as discussed in Hypothesis 3. Table III details the share-depth composition of the time-weighted aggregate inside market for the sample both in 2001 and in 2002. ECNs provide the lion's share of quoted depth to the inside market: almost 78% of the displayed share depth in the 2001 sample week, and over 71% during the 2002 sample week[9], although the aggregate proportion of trades on ECNs is

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[7] Mean market capitalization is just over $19 billion in 2001, and around $18 billion in 2002.
[8] Because market participants only quote their willingness to trade at their best prices, the montage consists of an aggregation of "top of the book" records. Consequently, market depth away from the inside is incomplete.
[9] Although the displayed depth of ECNs is quite large, the fill rates for ECN orders is relatively low – Hasbrouck and Saar (2001) report a mean fill rate at the inside of around 10 percent. Limit orders on ECNs are frequently "fleeting orders", persisting for a few seconds, then withdrawn if unfilled.

much lower (around 30 percent in the Nasdaq 100[10]). Wholesalers, wirehouses, and investment banks each provide around five percent of displayed market depth in 2001 and 2002; however, investment banks and wirehouses contribute disproportionately to reserve size: when hidden depth is included, investment banks provide over 16 percent of the total inside depth, and wirehouses nearly 9 percent. Although any ECN can chose to be auto-executable through the SuperSOES system (a prerequisite to quoting reserve size), only one ECN is auto-executable. Consequently, reserve depth on ECNs is understated to the degree that it does not include hidden orders (those marked for non-display to the NNM). It is unlikely that the magnitude of hidden orders is large: Hasbrouck and Saar (2001) report that execution of hidden orders comprises around 3 percent of Island share volume. The latter panel of Table III details the representation of different market-maker categories in the near inside market (the next best five ticks on each side of the NBBO.) ECNs contribute substantially to the near-inside market (providing nearly 45 percent of the displayed depth), but substantially less than their 71 percent contribution to the inside market. The reserve depth at ticks near but away from the inside is more proportional to quoted depth, with the exception of investment banks, who do not display a substantial portion of their depth away from the inside.

There are a number of possible stories for why reserve size is used differently for different types of market participants. It may be that certain market participants are more concerned about signaling the market as to their trading intentions. Alternatively, some market participants may use reserve size because they tend to have large orders to work, and quoting reserve size allows them to work these orders as a liquidity provider rather than a liquidity demander, minimizing transaction costs. A further possibility is that hidden size may be used speculatively when a

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[10] See the Nasdaq Trader web site at www.nasdaqtrader.com for data on month-by-month trading activity of market participants including ECNs.

market participant anticipates a news event. Further discussion of this is deferred to the results and conclusions sections.

III. Methodology and Results

A. Market depth

Hypothesis I states that the ability to conceal order size will mitigate the adverse selection costs of liquidity suppliers, resulting in an increase in the aggregate depth provided to the market. To test this hypothesis, I compare total quoted liquidity in the Nasdaq 100 during two sample periods. The pre-sample occurs from June 11-15, 2001; the post sample is April 22-26, 2002. Both samples are post-decimalization. To control for changes in the aggregate market, I construct a matched sample with NYSE firms and compare the change in quoted (displayed and reserve) depth after adjusting for changes to displayed depth with the NYSE matched firm.

I perform two tests for depth change. In the first test, matching firms are selected on five criteria: market capitalization, price, institutional ownership[11], volatility and dollar-volume. The second matching scheme (to check robustness to different matching criteria) uses only market capitalization and institutional ownership.

Let X_{Ni} represent a NYSE firm's value for characteristic i and X_i represent a Nasdaq sample firm's value for characteristic i. NYSE firms are selected to minimize the following function:

$$\text{SCORE} = \Sigma^{4}_{i=1}(X_{Ni}-X_i)^2 / X_i \qquad (1)$$

[11] Institutional ownership data is from Media General Financial Services, a data vendor who compiles information from EDGAR filings. The most recent institutional ownership data available is from mid-1991 – one to two financial quarters later than data used for market capitalization.

Table IV presents the matched sample and the results of the depth comparison. Both displayed and total time-weighted near-inside dollar depth for the Nasdaq stocks is reported, as well as the change in the time-weighted dollar depth of the NYSE specialist of the matched first (matched depth change). Under the first matching scheme (stocks are matched on size, volatility, price, volume and institutional ownership), 72 of the 97 Nasdaq sample stocks show a greater percentage increase in displayed depth than their NYSE match firm. However, when reserve size is included in the Nasdaq market depth, 84 stocks show a larger percentage increase in depth than their NYSE counterparts. The mean displayed depth increase for the sample stocks is 21 percent; during the same time period, the matched NYSE firms' specialists had a 20 percent *decrease*[12] in quoted depth. When reserve size is included in the comparison of the aggregate market depth, the Nasdaq firms showed a mean 57 percent dollar depth increase during the period; the median depth change is 39 percent.

Under the second matching algorithm (using only market capitalization and institutional ownership), the NYSE matched stocks showed a 12 percent dollar depth decrease during the sample time. 65 Nasdaq firms showed a displayed depth change that exceeded that of their NYSE matched firm; if non-displayed depth is included, 78 firms exceeded the depth change of their NYSE counterpart.

This evidence supports the hypothesis that the ability to quote depth that is not displayed increases market depth, but there are confounding factors. The comparison between the aggregate pool of Nasdaq market makers and a single NYSE specialist is a rough one at best. The participation rate for Nasdaq market makers in Nasdaq market trades is significantly higher than the participation rate of NYSE specialists in the trades of NYSE firms. The comparison is made between the normal mode of trading for Nasdaq, and the liquidity provider of last resort for NYSE issues. Furthermore, although the reserve size feature has only been recently systematically implemented, the ability to trade in excess of posted size has always been available to Nasdaq market makers[13]. The additional liquidity provided in hidden size may have always been available as depth improvement to an order submitted to a market maker; however, with the reserve feature in SuperSOES, this additional liquidity is auto-executable and thus accessible without requiring a broker to search for liquidity. Although the comparison is not a perfect one, the evidence supports the hypothesis that additional liquidity is provided to the market via the hidden-size provision of SuperSOES.

B. Cross-sectional Determinants of Hidden Depth

Hypothesis 2 states that the use of reserve-size should be highest for those stocks with the highest probability of informational events, since liquidity providers in these securities face the highest adverse selection costs. Hypothesis 3 states that we should observe more hidden depth in securities with higher volatility of returns. To test these hypotheses, I run a series of Tobit regressions of determinants of the proportion of liquidity that is not displayed within one cent of the NBBO for the 97 sample stocks. In addition to various proxies for the probability of informational events, I include dollar trading volume and market capitalization as control variables.

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[12] In February 2002, the NYSE implemented OpenBook, which allowed other market participants to observe limit orders, which had previously only been visible to the specialist. There was an approximately five percent decrease in specialist dollar depth around this event.

[13] NYSE specialists can also trade in excess of their posted depth. For a discussion of NYSE liquidity see Werner (2003).

Because the probability of information events is not observable, several proxies are used in the regressions, namely midquote volatility (both contemporaneous and lagged), and beta and variance for the error term from a market model regression[14] of the form:

$$R_{i,t} = \alpha_i + \beta_i R_{Mi,t} + \varepsilon_{i,t} \qquad (2)$$

where $R_{i,t}$ is the return on stock i at time t, α_i is a stock-specific intercept, and $R_{Mi,t}$ is the return on the Nasdaq 100 Index (proxied by the QQQ security) at time t. Market model regressions cover the period from Jan 1, 2002 to March 31, 2002 using daily returns.

Results of the regressions are reported in Table V. The models suggest that the probability of an information event will be positively correlated with the use of reserve size by liquidity providers. In the regressions that use midquote volatility (both concurrent and lagged, see columns A and D), volatility is negatively associated with the proportion of hidden size in the cross-section. However, the market model residual, which theory suggests as a measure of idiosyncratic risk, is positively and significantly related to the use of hidden size (see column C). Market-model beta (a measure of market-related volatility) does not enter significantly in the regression (column B).

If the use of reserve size is governed by volatility, one might expect the residual term from the market model to enter into the regressions in a fashion similar to volatility itself, considering that the market model generally has poor explanatory power for Nasdaq stocks in particular. If hidden size were primarily used by market participants attempting to acquire or unwind positions without information as a liquidity provider rather than as a liquidity demander, we might expect to see a positive relationship, since the probability of a limit order being filled increases with volatility.

[14] I follow Hasbrouk and Saar (1991) in using the market model residual variance as a measure of idiosyncratic risk likelihood.

However, the data suggests the opposite relationship. Idiosyncratic risk (as proxied by the market model residual) is positively correlated with hidden size, yet all other volatility measures (beta and midquote volatility) are negatively associated with the use of hidden size. This suggests reserve size is used by market participants considering the possibility of firm-specific informational events, or perhaps strategically by traders who anticipate information and wish to trade upon it without paying the costs of demanding liquidity. Finally, there remains the possibility that the relationship between hidden size and volatility may be circular, in that the presence of hidden size serves to dampen return shocks.

C. Trading Costs and Informational Efficiency

Hypothesis 5 states that the information impact of an order decreases when a greater proportion of order size is not displayed. To test this hypothesis, I regress spread and price impact measures on variables that describe the trade itself and the market at the time of the trade (quoted half-spreads, trade size, the square of trade size, a stock-specific intercept, the depth imbalance at the inside market, and the quoted and hidden size with which the trade interacts – see Appendix A for variable definitions[15]). Several of these variables have been shown to affect trading costs and information impact previously (size, depth imbalance and quoted half-spread variables). The depth at the inside and hidden depth at the inside is that on the side of market with which the trade interacts; trades are classified as buys or sells based on the Lee-Ready algorithm, using the one second lagged midquote as a reference price[16]. Less than five percent of trades cannot be classified using this methodology; those trades that cannot be classified are excluded from the regression. For trades classified as "buys", the inside depth (both displayed and hidden) are from the ask side of the NBBO; for "sells", the depth is from the bid side. Both depth measures (and

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[15] All RHS variables are measured as a percent of the midquote at one second before execution.
[16] Nasdaq Economic Research has determined that a one-second midquote lag is optimal for SuperSOES trades.

depth imbalance) include depth within one cent of the NBBO, which should mitigate the effects of "pennying"[17] on results.

Table VIa presents results of these regressions. In addition to the mean coefficient for the stock-by-stock regressions, I report a mean t-statistic and a count of the number of stocks for which the individual t-statistic exceeds 1.96 if the coefficient is positive, or is less than –1.96 if the coefficient is negative. The first measure of trade execution costs is effective half spread (EHS), which captures the spread that is actually incurred by the trade. Consistent with previous literature on trading costs, EHS is increasing (but concave) in trade size, and increasing in quoted half-spread. None of the depth measures (imbalance, displayed or reserve size) enter significantly. These results show that the actual immediate trade cost is not affected by the presence (absence) of reserve size and is independent of book depth (after trade size is accounted for, as large trades typically execute at a higher spread).

The story for realized half-spreads (RHS) is quite different. Realized half-spreads are measured at 30 and 300 seconds post-trade; they take into account the movement of the midquote after the trade and include both the spread and the information impact (the change in the midquote that occurs post-trade). The results for trade size variables and QHS are consistent with those for EHS; however, depth imbalance is negative and significant for RHS. A positive depth imbalance arises when the depth on the side of the NBBO with which the trade interacts is greater than the opposing side of the market; for instance, when a buy order trades against an ask depth that exceeds the bid depth. The negative coefficient is expected, as the price impact of a trade at a time with positive depth imbalance should be less since liquidity providers are in aggregate more willing to make such trades. The quoted depth with which the trade interacts does not enter

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[17] Pennying is the practice of posting a quote or a limit order that improves the NBBO by one cent, effectively stepping ahead of other

significantly; however, the reserve depth is significant and positive, indicating that a trade which executes when there is large reserve size on the relevant side of the market pays a higher realized spread (the market tends to move against the trade in the five minutes post-trade).

For information content, the results are more dramatic. I measure information content (IC) as the percent change in the midquote following a trade at 30, 300 and 1800 seconds. A positive IC means that the midquote changed in the direction of the trade: an upward price revision following a buy order, a negative price revision following a sell order. For IC, trade size is not significant: if we view RHS as an aggregation of EHS and IC, the EHS portion seems to capture the order-size effect. The quoted depth imbalance is significant, but positive: a buy order trading against a market with more depth on the ask side has a larger price impact, and additional depth on the ask side of the market (quoted depth) is also positive but only weakly significant. Reserve size at the inside market is highly significant and negative: for a buy order trading against non-displayed size, the market is far more likely to move downward in the post-trade period. In all sample stocks, trading against non-displayed size is "bad news" for a trade: the market is likely to move down following a buy, or increase following a sell. For 90 stocks this is true five minutes post-trade, and for 65 stocks it is true after 30 minutes.

Hypothesis 4 states that the market participants whose quotes are most informative should choose to hide more depth than other market-makers. To test this, I present similar regressions in Table VIb, but with liquidity broken down by market participant type. The displayed and hidden depth for all market-maker types does not significantly impact effective half-spreads. For realized half-spreads, only the displayed depth of ECNs enters significantly in regressions on realized half-spreads after 30 seconds – the mean coefficient is positive and significant, but it is significant for

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liquidity providers to get price priority for execution. This is very common for ECN quotes.

a minority of stocks, suggesting that the role of ECNs in trading is not consistent in the cross-section. At five-minutes post-trade, the effect is no longer significant. The hidden depth (but not displayed depth) of wirehouses and investment banks is also significantly and positively related to realized half spreads both at 30 seconds and five minutes post-trade, but only for a minority of issues.

For the information impact of the trade itself (midquote change post trade), the results are more dramatic. For all market participant categories (excepting perhaps major regional brokers), displayed depth has a significant effect on midquote revision post-trade at 30 seconds. Quoted depth is positively associated with price impact for all participant types except ECNs; this is consistent with Huang (2002) who observes that ECN quote revisions tend to lead Nasdaq market maker quote revisions. This effect does not persist beyond 30 seconds, however. For non-displayed depth, the depth of wholesalers, wirehouses, investment banks and "other" market participants is significant and negative at short time horizons. The effect is most persistent for investment banks and wirehouses[18], whose non-displayed depth continues to be associated with negative trade price impact 30 minutes post trade: the non-displayed depth of these categories is indicative that the market will move against the trade in the half-hour that follows.

Although it is clear that there is a complex interaction between the depth imbalance and quoted and hidden depth measures in these regressions, the results do suggest an important role for reserve size in trade execution quality. First, quoted depth does not matter: for all measures of trade impact (EHS, RHS, IC), aggregate quoted depth does not enter significantly. Imbalance plays a role in realized spreads and information content – mitigating the trading costs when a trade interacts with the deeper side of the market, but increasing midquote impact in the wake of a trade. The role of reserve size is quite marked: the presence of hidden depth on the relevant side of the market is a strong indicator that the market will move against the trade – down following a buy order, or up following a sell order. This is most likely when the market participants quoting the hidden size are wirehouses or investment banks – those most likely to be working large, institutional orders.

D. Hidden Size, Information and Events: Earnings Releases

It is clear that the use of reserve size – particularly by investment banks and wirehouses – is predictive of short-term future price movements. However, questions remain about the horizon of the information in reserve size quotations, and whether this information relates to fundamentals of asset value, or merely knowledge of short-term order imbalances that may have a transient effect on market prices. To test these questions, I construct portfolios using reserve size imbalances in a methodology akin to that in Griffin, Harris, and Topaloglu (2003).

Using daily data from January to July 2002, I construct a time-weighted measure of reserve imbalance. Let T_{Bit} (T_{Ait}) represent the sum of the share depth quoted for stock i by all market participants' bid (ask) quotes that are within one cent of the NBBO at each second of the trading day, t. Define the depth imbalance measure for stock i on day t as:

$$\text{Imbalance}_{i,t} = (T_{Bit} - T_{Ait}) / (T_{Bit} + T_{Ait}) \qquad (3)$$

This measure is constructed for each Nasdaq 100 stock for each trading day, and the stocks are ranked daily by the magnitude of this measure. I form five portfolios based on the rankings.

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[18] Huang finds that the displayed *price* quoted by wirehouses is more informative than the displayed prices of other classes of market-makers. I find the non-displayed *depth* of investment banks and wirehouses is more informative in the 30 minutes post-trade.

Equally weighted portfolio returns (in excess of the return on the Nasdaq 100) are calculated for the day of portfolio formation, and the two preceding and following days.

Table VII reports portfolio returns when this measure is constructed using only displayed depth; the H-L row reports the difference between the “high” portfolio (formed of stocks with disproportionate depth quoted in bid quotes) and the “low” portfolio (formed of stocks with disproportionate depth in ask quotes). For each day, I perform a Wilcoxon Signed Rank Test of the hypothesis that the mean return in the “high” portfolio exceeds the mean return in the “low” portfolio. The first panel reports portfolio returns when the quotes of all market participants are included. The only null rejection occurs on day –1, the day preceding portfolio formation; in aggregate, the market’s displayed depth is buying yesterday’s “winners” and selling yesterday’s “losers”. The portfolio return on the day of portfolio formation is – 1.2%; if we were to trade on this signal, even before adding trading costs (other than the spread which is included in this return), the strategy would have negative returns. The second panel repeats the test, but uses only the quotes of investment banks and wirehouses to construct the ranking measures, with similar results. The third panel shows the results when the measure is constructed using the quotes of all non-ECN market makers who are not classified as investment banks or wirehouses. On the day of portfolio formation, the H-L portfolio has a return of –1.4%, but the day –1 return is zero.

Table VIII repeats the experiment in Table VII, but uses reserve (hidden) depth rather than displayed depth to construct the imbalance measure used to rank stocks and form portfolios. In aggregate, the reserve quotes of market participants are again buying yesterday’s “winners” and selling yesterday’s “losers”. However, on the day of portfolio formation, the H-L portfolio has a positive and significant return of 2.3%. The two remaining panels of Table VIII show that the positive signal about which stocks will rise or fall in price today is almost entirely contained in the reserve depth quotations of investment banks and wirehouses.

These results suggest several things. First, the aggregate market's quoted depth is related to yesterday's price movements. This may be a function of the market behaving like a momentum investor, or it could be that the buy/sell imbalance in displayed depth is an artifact of market participants not going home "flat" – they may carry over an inventory from the previous day's trading and quote more aggressively on one side to try to unwind the position. Regardless, the buy/sell signal contained in displayed depth is not indicative of how a stock will perform on the present day, or the two days which follow. Second, the story for reserve size is quite different. Reserve size does predict how a stock will fare on the present day; if we could observe the non-displayed depth quoted by market participants, we would gain information on which stocks are likely to increase in value, and which are likely to fall in value. Finally, the information content in these hidden quotes is not of equal quality across classes of market participants. Investment banks and wirehouses – be it from information acquisition or observance of the signal in their own order flow – seem to know more about which stocks will fare well (or poorly) on a given day and incorporate this signal into their quotation strategy. It is also possible that reserve size use is indicative of these market makers working a large institutional order over the course of several days, and it is the order itself which creates the price impact. Nevertheless, if we could observe this signal, we would know something more about price movements today. However, what we cannot know is whether the information they seem to possess allows them to trade profitably; the reserve quotes themselves may not translate into transactions. It may be that these market participants have a desire to buy or sell stocks that will change in price, but that the fill rate for these quotes is disproportionately low and does not translate into profitable transactions.

The tests of Tables XIII and IX shed some light on the horizon of information in quotes, but they do not speak to the question of the nature of the information. Is this an artifact of inventory considerations, or is this information about fundamental asset value? In order to examine this, I repeat the exercises of Tables XIII and IX, but use only days of earnings announcements. Earnings data for all Nasdaq 100 stocks from January-July of 2002 is obtained from IBES; the time of the earnings announcement is taken from Factiva, which captures the time stamp of the news wire story of earnings release. The event day is the first trading day in the wake of the earnings announcement; if earnings are released after the market closes (4:00 EST), then the following day becomes day zero[19].

Table IX reports event-time portfolio returns for the 261 earnings releases during my sample, where imbalance measures are calculated using displayed size. Note that the pattern of buying yesterday's winners and selling yesterday's losers is absent in the earnings announcement event time. Also, displayed depth on the first day of trading post-announcement has no signal for which stocks will increase or decrease in price. Assuming that the opening quotes' prices reflected any surprise contained in the announcement itself, all classes of market participants are buying yesterday's losers, selling yesterday's winners and the H-L portfolio created based on the signal in *displayed* depth shows negative returns. These results are consistent with the notion that the market overreacts to news in earnings announcements and later corrects itself (Jegadeesh and Titman, 1993).

Table X repeats the test of Table IX, but uses reserve size rather than displayed size. The pattern of buying (selling) yesterday's winners (losers) is absent. The H-L portfolio for the market shows a positive return of 2.7%, which is almost entirely attributable to the reserve size quotes of

[19] Only one of 261 announcements occurs during market hours. The announcement time is approximately 10:00 AM and the day of

investment banks and wirehouses. The H-L portfolio for other market-makers has a zero return on the day of portfolio formation, and the day –1 returns for market-makers other than investment banks and wirehouses is negative. Clearly, the use of reserve size at earnings announcements differs across types of market makers, with investment banks and wirehouses only posting hidden quotes that are informative about the returns on the first trading day in the wake of the news event. Again, it is possible that the trading interest signaled by the use of reserve size is not fulfilled (the reserve size has a low fill rate compared to what would normally be expected), but the information therein is quite different from what the rest of market evidences. It is possible that this is due to large orders being carried over from the day prior to earnings release (an interesting result in and of itself considering the pre-earnings drift frequently documented in the literature), or the information could reflect a more accurate interpretation of the news event (absent of the overreaction seen in the displayed quotes).

IV. Conclusions

This study is the first to describe the hidden-size feature of SuperSOES, and to measure its impact on trading characteristics. I show that hidden size adds substantial liquidity to the market, primarily through additional size quoted by investment banks and wire houses. Consistent with theoretical predictions, hidden size is used more for stocks with a higher probability of an informational event, as proxied by the market-model residual; volatility is negatively associated with hidden depth.

Hidden size does not affect the effective half-spreads incurred by trades, yet it seems to play a role in trade-execution quality in information impact of trades. The presence of hidden depth at

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announcement is used as day zero.

the time of a trade is a significant predictor of midquote revision: the market is more likely to move against a trade in the 30 minutes following a trade when reserve size is used on the side of the NBBO opposite the trade; displayed depth has no such role. This suggests that hidden size is highly predictive of market price movements – it is, in effect, the trading of "smart money", selling before the market moves down, buying before the market moves up. It is possible that this effect is due to hidden size being used as a vehicle for certain market participants (investment banks and wirehouses) to work large orders as a liquidity provider rather than a liquidity demander. The use of reserve size does not appear to be related to events that may affect the fundamental value of a stock (i.e. earnings announcements).

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Appendix A
Variable Definitions

Depth	Half of aggregate displayed depth for all market maker quotes within one cent of the best bid or ask
MM	Number of market participants (including ECNs, regional exchanges and order entry firms) quoting during the sample period
Volume	Sum of all media-reported trades excluding those later cancelled or modified. As-of trades are included in this sum.
PIN	Stock-specific risk proxy, the square root of market-model residual
Price	Time-weighted mean of bid-ask midpoint
Volatility	Second-by-second standard deviation of bid-ask midpoint
MktCap	Market capitalization as of April 1, 2002
Rdepth	Half of aggregate reserve depth for all market maker quotes within one cent of the best bid or ask
Spread	(Best ask - best bid)/(midpoint) in basis points
EHS	Effective half-spread. .5*(transaction price - one second lagged midpoint)/midpoint* buy indicator variable
Buy	1 for buy orders, -1 for sell orders categorized by Lee-Ready algorithm
Size	Transaction quantity in shares
$Size^2$	Square of transaction quantity in shares
QHS	Quoted half-spread. .5*(best ask-bestbid)/(midpoint)
Dimbal	Depth imbalance at trade time. (Ask-side depth - bid-side depth)/(ask-side depth+bid-side depth)*buy indicator variable where depth is within one cent of NBBO
Reldepth	Depth within one cent of best ask for buy orders, on bid side for sell orders
Resreldepth	Reserve depth within one cent of best ask for buy orders, on bid side for sell orders
IC_n	Information impact of trade after n seconds. (midpoint n seconds post-trade - midpoint at trade time)/(midpoint at trade time)*buy indicator variable.
RHS_n	Realized half-spread after n seconds. (.5*(transaction price - n second lagged midpoint)/midpoint at trade time* buy indicator variable)

Table I
Characteristics of Sample Stocks

This table presents sample characteristics for the 97 Nasdaq 100 stocks that were listed in June, 2001. Market makers is the number of market participants submitting quotes to the Nasdaq National Market. Vol/Price is the standard deviation of the midpoint price scaled by the stock price (a percent volatility measure.) Market capitalization data is from the Nasdaq's ComFin database.

	2001				2002			
TSEC	Market Makers	Price	Vol/Price	Market Cap (000's)	Market Makers	Price	Vol/Price	Market Cap (000's)
AAPL	89	20.33	0.03	8,114,785	81	24.20	0.02	22,451,911
ABGX	46	39.29	0.06	3,867,120	62	14.82	0.07	2,339,888
ADBE	67	40.76	0.04	11,226,608	68	37.92	0.01	16,168,314
ADCT	84	7.70	0.06	5,209,802	87	3.84	0.05	7,167,256
ADRX	42	69.02	0.04	5,395,929	62	44.31	0.02	5,819,149
ALTR	72	26.03	0.03	11,215,808	81	20.91	0.02	21,512,317
AMAT	97	52.67	0.02	39,924,536	101	25.40	0.02	41,257,197
AMCC	90	17.02	0.04	5,168,376	90	6.95	0.07	4,657,771
AMGN	87	66.71	0.02	63,540,516	96	55.76	0.01	50,225,514
AMZN	85	14.14	0.09	5,082,553	94	15.67	0.06	6,545,886
APOL	46	35.78	0.07	4,924,115	50	53.61	0.16	12,605,877
ATML	75	11.65	0.06	6,258,780	80	9.26	0.04	6,177,051
BBBY	64	29.59	0.03	9,029,249	66	36.38	0.02	26,477,139
BEAS	84	33.84	0.07	12,105,421	95	11.20	0.05	7,973,581
BGEN	72	64.16	0.03	8,079,364	80	42.60	0.02	14,180,219
BMET	55	45.48	0.03	8,600,049	65	27.65	0.01	19,034,987
BRCD	86	42.92	0.04	10,031,568	90	24.38	0.02	10,711,530
BRCM	84	34.60	0.04	7,745,418	89	35.35	0.03	11,288,939
CDWC	37	39.16	0.15	3,403,147	47	53.40	0.01	8,920,848
CEFT	56	52.35	0.04	12,603,011	69	32.28	0.02	35,146,001
CEPH	47	66.59	0.06	3,494,121	60	61.78	0.03	5,930,342
CHIR	56	49.16	0.02	9,683,574	65	42.52	0.04	21,581,192
CHKP	78	44.61	0.03	11,866,251	96	18.51	0.02	8,133,634
CHTR	69	22.88	0.04	7,428,009	79	8.76	0.08	5,158,390
CIEN	92	48.43	0.06	12,407,684	104	7.83	0.03	5,644,746
CMCSK	62	40.89	0.02	39,677,539	73	27.75	0.03	23,423,827
CMVT	72	62.32	0.04	9,786,198	82	12.26	0.03	4,398,012
CNXT	69	8.61	0.08	2,211,411	84	11.04	0.07	5,630,872
COST	66	40.15	0.01	18,523,917	77	40.47	0.02	18,119,657
CPWR	59	11.82	0.06	5,180,735	68	8.08	0.03	3,551,744
CSCO	118	18.92	0.04	133,205,236	120	14.49	0.01	68,962,669
CTAS	44	45.85	0.03	7,817,823	51	51.46	0.01	19,569,683
CTXS	74	27.43	0.05	6,445,856	78	13.13	0.12	5,936,195
CYTC	41	24.47	0.06	2,641,161	64	21.63	0.22	6,179,206
DELL	109	25.28	0.02	68,084,035	105	26.78	0.01	48,065,087
DISH	61	27.92	0.07	7,674,106	61	27.72	0.02	13,249,653
EBAY	75	63.35	0.02	18,503,601	82	52.12	0.01	20,207,885
ERICY	88	5.19	0.06	6,467,074	89	2.50	0.05	4,530,447
ERTS	56	57.44	0.03	7,893,102	71	59.48	0.02	15,520,979
ESRX	40	106.05	0.03	4,311,601	49	62.18	0.02	8,125,588
FISV	57	56.69	0.03	7,955,273	60	43.41	0.01	19,167,338
FLEX	80	23.10	0.07	12,596,300	86	14.66	0.05	15,764,792
GENZ	50	53.41	0.03	11,694,066	64	40.87	0.02	20,461,855
GILD	42	50.04	0.03	5,510,418	56	32.84	0.05	12,053,816
GMST	57	37.45	0.05	17,550,433	67	10.86	0.09	9,234,188
HGSI	57	66.71	0.03	7,684,707	68	16.63	0.06	4,070,191
ICOS	39	62.04	0.04	3,384,448	54	41.53	0.04	4,680,944

Table I (continued)
Characteristics of Sample Stocks

This table presents sample characteristics for the 97 Nasdaq 100 stocks that were listed in June, 2001. Market makers is the number of market participants submitting quotes to the Nasdaq National Market. Vol/Price is the standard deviation of the midpoint price scaled by the stock price (a percent volatility measure.) Market capitalization data is from the Nasdaq's ComFin database.

	2001				2002			
TSEC	Market Makers	Price	Vol/Price	Market Cap (000's)	Market Makers	Price	Vol/Price	Market Cap (000's)
IDPH	55	69.24	0.03	10,102,259	70	58.97	0.04	19,042,721
IDTI	54	32.69	0.11	3,353,341	64	29.34	0.05	5,692,533
IMCL	47	48.74	0.05	3,550,325	69	18.15	0.13	2,791,396
IMNX	74	15.17	0.03	9,623,393	74	28.42	0.01	39,243,504
INTC	99	28.97	0.02	196,794,000	101	29.38	0.01	130,143,875
INTU	61	35.99	0.03	8,363,629	62	38.79	0.02	19,668,221
ITWO	88	19.67	0.10	8,139,166	91	3.43	0.09	2,900,569
IVGN	35	74.06	0.04	3,763,110	48	33.17	0.04	3,039,811
JDSU	104	14.26	0.06	14,289,625	114	5.04	0.05	13,899,447
JNPR	98	33.65	0.03	9,975,076	104	10.68	0.03	4,209,376
KLAC	78	56.11	0.02	10,839,519	82	61.78	0.02	26,915,070
LLTC	60	49.95	0.04	14,055,813	73	39.87	0.02	32,307,442
MCHP	45	24.99	0.06	4,407,211	54	44.52	0.02	9,393,456
MEDI	57	41.08	0.04	10,088,198	62	35.02	0.02	17,705,854
MERQ	54	59.75	0.07	4,948,639	71	37.08	0.02	5,971,806
MLNM	63	34.31	0.06	7,744,272	78	20.14	0.07	11,828,438
MOLX	37	33.91	0.05	3,616,287	48	33.57	0.01	6,097,140
MSFT	96	70.34	0.02	392,893,446	95	54.06	0.01	189,008,731
MXIM	58	51.10	0.04	14,514,143	69	51.36	0.02	45,121,019
NTAP	77	16.61	0.08	4,521,548	85	16.78	0.02	11,063,218
NVDA	61	94.49	0.02	6,507,433	79	34.70	0.04	10,449,418
NVLS	73	53.14	0.03	8,089,849	80	49.01	0.02	13,602,206
NXTL	79	14.72	0.04	12,764,098	102	5.24	0.03	9,870,482
ORCL	120	15.63	0.03	106,657,925	113	10.96	0.02	47,877,504
PAYX	58	37.39	0.03	14,932,920	67	38.39	0.01	25,683,318
PCAR	38	49.21	0.03	3,935,687	42	72.24	0.01	11,659,540
PDLI	53	78.24	0.04	3,790,544	68	18.70	0.05	3,049,683
PMCS	73	31.31	0.06	5,097,624	82	16.20	0.04	5,613,508
PSFT	74	42.16	0.04	14,472,882	90	22.88	0.03	18,939,082
QCOM	94	55.01	0.05	44,285,325	94	33.47	0.02	56,050,306
QLGC	74	55.00	0.04	5,959,240	80	47.22	0.02	8,442,469
RATL	50	24.73	0.05	5,699,508	65	14.70	0.05	5,505,679
RFMD	75	24.23	0.07	4,443,739	82	17.69	0.03	6,313,069
SANM	68	23.41	0.07	7,483,943	79	11.37	0.04	12,591,560
SBUX	61	19.49	0.02	8,743,772	76	25.04	0.02	25,133,805
SEBL	81	44.08	0.05	21,136,892	99	24.75	0.03	25,616,193
SEPR	43	34.16	0.07	3,097,634	57	14.82	0.07	2,250,811
SNPS	46	56.98	0.06	2,944,870	55	48.41	0.04	5,142,285
SPLS	66	14.31	0.02	7,308,373	70	20.51	0.02	11,902,198
SPOT	41	36.59	0.07	5,822,397	41	23.47	0.02	8,914,866
SSCC	35	14.86	0.03	3,946,757	46	16.09	0.05	7,317,972
SUNW	106	16.38	0.03	51,196,959	113	8.67	0.02	23,490,962
SYMC	57	59.98	0.13	3,177,792	77	35.90	0.02	9,842,804
TLAB	79	26.99	0.09	7,941,401	81	8.80	0.02	3,845,053
TMPW	55	59.51	0.05	6,101,280	64	30.14	0.02	7,081,196
USAI	45	25.29	0.03	8,664,824	56	31.32	0.02	22,141,081

Table I (continued)
Characteristics of Sample Stocks

This table presents sample characteristics for the 97 Nasdaq 100 stocks that were listed in June, 2001. Market makers is the number of market participants submitting quotes to the Nasdaq National Market. Vol/Price is the standard deviation of the midpoint price scaled by the stock price (a percent volatility measure.) Market capitalization data is from the Nasdaq's ComFin database.

	2001				2002			
TSEC	**Market Makers**	**Price**	**Vol/Price**	**Market Cap (000's)**	**Market Makers**	**Price**	**Vol/Price**	**Market Cap (000's)**
VRSN	73	53.00	0.05	12,054,269	83	18.40	0.19	8,933,364
VRTS	82	64.72	0.04	26,439,887	90	28.15	0.03	21,943,291
VTSS	74	21.39	0.08	3,857,621	88	6.66	0.12	2,835,747
WCOM	111	16.66	0.04	41,010,381	112	3.60	0.04	6,820,959
XLNX	74	43.24	0.03	13,716,094	85	38.63	0.02	32,581,881
YHOO	86	17.31	0.05	11,332,431	92	14.37	0.02	7,502,547
Mean:	67.89	39.64	0.05	19,286,891	76.65	28.15	0.04	18,111,139
Median:	67.00	37.45	0.04	8,079,364	78.00	26.78	0.02	11,063,218
Std Dev:	19.95	20.03	0.02	46,441,582	17.66	16.66	0.04	24,564,380
Min	35	5.19	0.01	2,211,411	41	2.50	0.01	2,250,811
Max	120	106.05	0.15	392,893,446	120	72.24	0.22	189,008,731

Table II
Near-Inside Depth for Nasdaq Stocks 2001 and 2002

Near-inside dollar depth for Nasdaq 100 stocks pre- and post- SuperSOES implementation. The sample is Nasdaq 100 stocks during April 2002. Dollar depth is equally weighted between stocks. The 2001 sample week is June 11-15, 2001; the 2002 sample week is April 22-26, 2002. The percent change for both displayed and total depth is reported, as well as the percentage of depth displayed at the next five penny ticks on each side of the NBBO.

	Displayed Depth			**Total Depth**		**2002 Percent**
	2001	**2002**	**Change**	**2002**	**Change**	**Displayed**
Bid - .05	14,039	19,718	40.45%	31,411	123.75%	62.77%
Bid - .04	11,883	25,570	115.19%	36,444	206.70%	70.16%
Bid - .03	13,239	25,063	89.31%	37,071	180.01%	67.61%
Bid - .02	14,924	26,694	78.87%	40,211	169.44%	66.38%
Bid - .01	18,002	27,386	52.13%	41,944	133.00%	65.29%
Best Bid	45,252	50,374	11.32%	66,661	47.31%	75.57%
Best Ask	49,925	50,740	1.63%	67,343	34.89%	75.35%
Ask + .01	12,118	19,041	57.13%	30,886	154.88%	61.65%
Ask + .02	11,896	24,089	102.50%	37,670	216.66%	63.95%
Ask + .03	12,054	24,214	100.87%	37,969	214.99%	63.77%
Ask + .04	7,664	18,170	137.07%	27,387	257.32%	66.35%
Ask + .05	11,541	21,148	83.24%	35,182	204.83%	60.11%

Table III
Inside Market Participant by Type

This table reports inside market participation by market participant category. The categorization is that used by Nasdaq Economic Research, and is detailed in an appendix. Depth is equally-weighted across all stocks in the sample, and is aggregated for both sides of the inside market (bid and ask side are summed.) For 2002, total depth includes reserve depth, which is not displayed.

	Inside Market		
	2001	**2002**	
Type	**Displayed**	**Displayed**	**Total**
Wholesaler	5.07%	4.88%	5.14%
I Bank	5.21%	5.80%	16.66%
Wire House	4.76%	4.69%	8.80%
Major Regional	1.66%	1.48%	2.86%
ECNs	77.74%	71.24%	54.50%
Other	5.55%	11.91%	12.03%
		Near-Inside Market	
Wholesaler	13.38%	9.33%	8.83%
I Bank	14.45%	14.60%	18.64%
Wire House	12.33%	10.09%	11.32%
Major Regional	4.09%	4.29%	4.57%
ECNs	42.63%	44.86%	40.45%
Other	13.11%	16.84%	16.20%

Table IV
NYSE/Nasdaq Depth Comparison from June 2001 to April 2002

This table shows a comparison of NASD100 stocks and the NYSE stock that best matches each based on price, trading volume, market capitalization, and volatility at the end of May, 2001. Displayed and total depth are calculated as half the total dollar depth within one cent of the NBBO on both sides of the market. Total depth includes reserve depth that is not visible to market participants. Match Depth Change is the ratio of NYSE specialist quoted dollar depth during the post SuperSOES sample to the same measure during the pre-sample.

Ticker	Depth 2001 ($)	Displayed 2002 ($)	Total 2002 ($)	Displayed Depth Change	Total Depth Change	Match Depth Change
Panel A: Matching Criteria: Size, Volatility, Price, Volume, Institutional Ownership						
Mean	47,854	51,266	67,791	1.21	1.57	0.80
Median	35,010	39,742	50,833	1.10	1.39	0.75
Std. Dev.	40,556	52,108	70,139	0.71	0.90	0.31
Firms with Total Depth Change > Match Depth Change:						84
Firms with Displayed Depth Change > Match Depth change:						72
Panel B: Matching Criteria: Size, Institutional Ownership						
Mean	47,854	51,266	67,791	1.21	1.57	0.88
Median	35,010	39,742	50,833	1.10	1.39	0.76
Std. Dev.	40,556	52,108	70,139	0.71	0.90	0.74
Firms with Total Depth Change > Match Depth Change:						78
Firms with Displayed Depth Change > Match Depth change:						65

Table V
Cross-Sectional Tobit Regressions of Proportion of Hidden Size

The dependent variable is the proportion of aggregate (bid and ask) quoted size within one cent of the NBBO that is not displayed (reserve size.) (Share) volume and midquote volatility are contemporaneous. Beta and market model residual is estimated for the preceeding six months. Lagged volatility is from the preceeding week. The sample is Nasdaq 100 stocks during April 22-26, 2002.

	A	B	C	D	E
Intercept (x100)	-36.2	-6.04	-2.04	**-44.71**	4.86
	0.10	0.79	0.93	0.04	0.85
Volume (x100)	5.38	1.91	0.62	**5.36**	1.05
	0.00	0.28	0.71	0.00	0.64
Market Cap (x100)	-3.03	-0.68	2.76	-2.63	-1.22
	0.08	0.73	0.21	0.11	0.50
Midquote Volatility (x100)	**-6.40**			-3.39	**-3.73**
	<.0001			0.08	0.04
Beta (x100)		1.20			
		0.61			
Market Model Error^2 (x100)			**9.16**		
			0.01		
Lag MQ Volatility (x100)				**-4.60**	
				0.01	
MMs (x100)					**0.22**
					0.01
Scale	0.10	0.10	0.10	0.09	0.09

Table VIa
Determinants of trading cost and price impact

Mean coefficients for regressions of effective half spread (EHS), realized half spreads(RHS) and information content (IC) on trade and market characteristics of trades of Nasdaq 100 stocks. Data is all media-reported NNM trades from 4/22/02-4/26/02. The statistic below the coefficient is the mean t-statistic, followed by the number of stocks for which the t-statistic exceeds 1.96 where the mean coefficient is positive, or the number of stocks with t-statistics below -1.96 where the mean coefficient is negative. Variable definitions are presented in an appendix.

	EHS	**RHS30**	**RHS300**	**IC30**	**IC300**	**IC1800**
Intercept (x1000)	**0.18**	0.05	0.02	**0.28**	**0.33**	**0.29**
	4.80 (76)	-1.64 (49)	-0.77 (41)	18.82 (96)	6.84 (94)	2.43 (53)
Size ($x10^7$)	**8.56**	**8.55**	**8.46**	0.03	0.21	-0.40
	9.98 (92)	8.68 (91)	5.99 (88)	-0.03 (10)	0.05 (10)	-0.13 (16)
$Size^2$ ($x10^{12}$)	**-6.86**	**-6.22**	**-5.67**	-1.27	-2.38	-3.10
	-4.34 (66)	-3.69 (67)	-2.53 (59)	-0.47 (13)	-0.27 (9)	0.02 (8)
QHS	**0.38**	**0.31**	**0.32**	**0.14**	**0.13**	-0.01
	14.05 (89)	9.51 (80)	6.46 (81)	6.89 (82)	2.04 (53)	-0.17 (27)
Depth Imbalance (x1000)	0.00	**-0.24**	**-0.29**	**0.49**	**0.58**	**0.54**
	0.46 (29)	-8.48 (86)	-6.98 (86)	32.18 (100)	12.64 (98)	5.24 (70)
Quoted Relevant Depth ($x10^6$)	0.37	4.00	-0.90	-7.25	2.55	29.78
	-0.40 (24)	-0.21 (24)	-1.17 (37)	0.49 (41)	1.69 (40)	1.51 (41)
Reserve Relevant Depth ($x10^6$)	2.58	**15.25**	**29.56**	**-25.34**	**-53.97**	**-65.66**
	-0.51 (15)	2.79 (55)	4.78 (72)	-11.76 (100)	-9.06 (90)	-5.10 (65)

Table VIb
Determinants of trading cost and price impact

Mean coefficients for regressions of effective half spread (EHS), realized half spreads(RHS) and information content (IC) on trade and market characteristics of trades of Nasdaq 100 stocks. Displayed and non-displayed depth at the inside is broken down by market participant category. Data is all media-reported NNM trades from 4/22/02-4/26/02. The statistic below the coefficient is the mean t-statistic, followed by the number of stocks for which the t-statistic exceeds 1.96 where the mean coefficient is positive, or the number of stocks with t-statistics below -1.96 where the mean coefficient is negative. Variable definitions are presented in an appendix.

	EHS	**RHS30**	**RHS300**	**IC30**	**IC300**	**IC1800**
Intercept (x 10^4)	**1.81**	0.45	0.17	**2.72**	**3.27**	2.83
	4.42 (73)	-1.66 (31)	-0.83 (27)	18.20 (97)	6.76 (95)	2.31 (50)
Size (x10^8)	**85.01**	**84.74**	**83.93**	0.54	2.16	-2.87
	9.92 (93)	8.62 (89)	5.95 (87)	0.08 (13)	0.10 (10)	-0.09 (9)
Size^2 (x10^{12})	**-6.76**	**-6.15**	**-5.56**	-1.23	-2.39	-3.21
	-4.31 (65)	-3.66 (66)	-2.51 (60)	-0.55 (13)	-0.31 (9)	-0.00 (8)
QHS	**0.38**	**0.31**	**0.32**	**0.13**	**0.12**	-0.01
	14.04 (88)	9.60 (81)	6.53 (82)	6.61 (82)	1.91 (52)	-0.16 (25)
Depth Imbalance (x10^3)	0.08	**-2.36**	**-2.82**	**4.90**	**5.80**	**5.16**
	0.94 (37)	-9.01 (88)	-7.32 (89)	34.90 (100)	13.52 (99)	5.48 (74)
<u>Displayed Depth</u>						
Wholesaler (x10^5)	0.83	-2.32	-4.05	**6.30**	9.76	15.22
	-0.15 (5)	-1.07 (30)	-1.26 (37)	3.17 (59)	1.91 (44)	0.32 (37)
I Bank (x10^5)	-0.63	-8.71	-9.46	**16.16**	17.67	20.48
	-0.27 (14)	-1.37 (34)	-0.89 (34)	3.74 (69)	0.93 (46)	0.95 (44)
Wirehouse (x10^5)	-3.51	-7.91	-13.51	**8.81**	20.02	32.32
	-0.62 (11)	-1.61 (35)	-1.83 (40)	3.21 (63)	2.25 (49)	1.60 (44)
Major Regional (x10^5)	-4.70	-20.84	-25.32	32.27	41.24	13.75
	-0.06 (3)	-0.63 (21)	-0.55 (28)	2.28 (45)	0.67 (39)	0.06 (37)
ECN (x10^6)	8.39	17.74	15.34	**-18.72**	-13.91	-11.70
	0.92 (28)	2.05 (41)	0.92 (33)	-4.62 (74)	-0.71 (38)	-0.12 (27)
Other (x10^5)	-3.75	-8.59	-8.07	**9.70**	8.65	23.87
	0.16 (9)	-1.33 (42)	-0.78 (33)	5.04 (75)	1.38 (44)	2.05 (45)
<u>Non-Displayed Depth</u>						
Wholesaler (x10^7)	2.18	4.91	8.33	**-5.48**	-12.30	-8.23
	0.11 (8)	0.90 (16)	1.23 (32)	-2.73 (69)	-2.03 (47)	-0.60 (31)
I Bank (x10^8)	-3.53	12.26	**22.16**	**-31.58**	**-51.38**	**-63.03**
	-0.13 (9)	2.12 (40)	2.90 (54)	-7.89 (94)	-5.10 (78)	-2.24 (51)
Wirehouse (x10^8)	-2.34	20.94	36.36	**-46.56**	**-77.41**	-97.52
	0.16 (3)	1.74 (27)	2.30 (41)	-5.83 (86)	-3.91 (67)	-2.38 (47)
Major Regional (x10^7)	-2.24	2.83	5.91	-10.14	-16.30	15.58
	-0.08 (6)	0.78 (12)	0.79 (19)	-3.27 (62)	-1.47 (36)	0.30 (27)
ECN (x10^7)	-5.09	2.50	-7.46	-15.17	4.75	-24.85
	-0.08 (3)	0.40 (11)	0.08 (12)	-2.17 (42)	-0.64 (14)	-0.85 (25)
Other (x10^7)	4.56	6.89	8.99	**-4.67**	**-8.87**	-3.81
	-0.23 (2)	1.09 (22)	1.36 (31)	-4.81 (75)	-2.56 (55)	-0.91 (39)

Table VII
Returns for Portfolios Classified by Displayed Bid-Offer Depth Imbalances

Using daily data from January-July 2002, the Nasdaq 100 stocks are assigned to five portfolios based on their bid-offer depth imbalance. The imbalance measure is (bid depth - offer depth)/(bid depth + offer depth), where depth is within one cent of the NBBO and is time-weighted throughout the trading day. This table reports the time-series average return of those portfolios in excess of the Nasdaq 100 return, expressed in percent per day. The final row (H-L) is the difference between the "high" portfolio (with the stocks with the highest bid imbalances) and the "low" portfolio (with the stocks with the highest ask imbalances.) Day zero is the day of portfolio formation. A * indicates statistical significance at the 5% level. The test is a one-sided test of the hypothesis that the excess returns of the "high" portfolio stocks have a greater mean than the distribution of returns of "low" portfolio stocks; the test is a Wilcoxon signed rank test. Panel 1 includes all non-ECN market makers. Panel 2 is only Investment Banks and Wirehouses. Panel 3 includes all non-ECN market makers that are not included in Panel 2.

Panel 1: All Market Maker Displayed Depth

	Day				
	-2	-1	0	1	2
High	-0.002	0.002	-0.008	-0.002	-0.001
4	-0.001	-0.002	0.000	-0.002	-0.002
3	0.000	-0.001	0.001	0.000	0.000
2	0.000	0.000	0.001	0.000	-0.001
Low	0.001	-0.001	0.004	0.001	0.001
H-L	-0.002	0.003*	-0.012	-0.002	-0.001

Panel 2: Investment Bank and Wirehouse Displayed Depth

	Day				
	-2	-1	0	1	2
High	0.001	0.007	-0.002	-0.001	0.000
4	0.000	0.003	-0.001	0.000	-0.002
3	-0.001	-0.001	0.001	0.000	-0.001
2	0.000	-0.005	-0.001	-0.001	0.000
Low	-0.002	-0.007	0.000	0.000	0.000
H-L	0.003*	0.014*	-0.001	-0.001	0.001

Panel 3: Other Market Makers Displayed Depth

	Day				
	-2	-1	0	1	2
High	-0.002	0.000	-0.009	-0.002	-0.001
4	-0.001	-0.002	0.000	-0.001	-0.002
3	-0.001	-0.002	0.000	-0.001	0.000
2	0.000	0.001	0.002	0.001	0.000
Low	0.001	0.000	0.005	0.001	0.000
H-L	-0.002	0.000	-0.014	-0.003	-0.001

Table VIII
Returns for Portfolios Classified by Reserve Bid-Offer Depth Imbalances

Using daily data from January-July 2002, the Nasdaq 100 stocks are assigned to five portfolios based on their bid-offer depth imbalance. The imbalance measure is (bid depth - offer depth)/(bid depth + offer depth), where depth is within one cent of the NBBO and is time-weighted throughout the trading day. This table reports the time-series average return of those portfolios in excess of the Nasdaq 100 return, expressed in percent per day. The final row (H-L) is the difference between the "high" portfolio (with the stocks with the highest bid imbalances) and the "low" portfolio (with the stocks with the highest ask imbalances.) Day zero is the day of portfolio formation. A * indicates statistical significance at the 5% level. The test is a one-sided test of the hypothesis that the excess returns of the "high" portfolio stocks have a greater mean than the distribution of returns of "low" portfolio stocks; the test is a Wilcoxon signed rank test. Panel 1 includes all non-ECN market makers. Panel 2 is only Investment Banks and Wirehouses. Panel 3 includes all non-ECN market makers that are not included in Panel 2.

Panel 1: All Market Maker Reserve Depth

	Day				
	-2	-1	0	1	2
High	-0.001	0.006	0.009	0.000	0.000
4	0.002	0.004	0.005	0.000	-0.002
3	0.000	0.001	0.001	0.000	0.001
2	-0.001	-0.005	-0.005	-0.001	-0.001
Low	-0.003	-0.009	-0.014	-0.002	-0.001
H-L	0.002*	0.016*	0.023*	0.001	0.000

Panel 2: Investment Bank and Wirehouse Reserve Depth

	Day				
	-2	-1	0	1	2
High	0.001	0.006	0.009	-0.001	-0.001
4	0.001	0.003	0.005	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000
2	-0.001	-0.003	-0.005	-0.001	-0.001
Low	-0.003	-0.009	-0.013	-0.002	0.000
H-L	0.004*	0.015*	0.022*	0.001	0.000

Panel 3: Other Market Makers Reserve Depth

	Day				
	-2	-1	0	1	2
High	-0.002	0.001	0.003	0.000	-0.001
4	0.000	0.002	0.000	-0.002	0.000
3	0.000	0.001	0.001	0.000	0.000
2	-0.001	-0.001	-0.001	-0.001	-0.001
Low	0.000	-0.006	-0.005	-0.001	-0.001
H-L	-0.001	0.008*	0.007*	0.001	0.000

Table IX
Returns for Portfolios Classified by Displayed Bid-Offer Depth Imbalances on Earnings Release Days

Nasdaq 100 stocks are assigned to five portfolios based on their bid-offer depth imbalance on the first trading day after the release of earnings news. The imbalance measure is (bid depth - offer depth)/(bid depth + offer depth), where depth is within one cent of the NBBO and is time-weighted throughout the trading day. Each daily return is in excess of the Nasdaq 100 return. This table reports the time-series average return of those portfolios, expressed in percent per day. The final row (H-L) is the difference between the "high" portfolio (with the stocks with the highest bid imbalances) and the "low" portfolio (with the stocks with the highest ask imbalances.) Day zero is the first trading day after earnings are released - the following day when earnings are announced after the market has closed.

A * indicates statistical significance at the 5% level. The test is a one-sided test of the hypothesis that the excess returns of the "high" portfolio stocks have a greater mean than the distribution of returns of "low" portfolio stocks; the test is a Wilcoxon signed rank test. Panel 1 includes all non-ECN market makers. Panel 2 is only Investment Banks and Wirehouses. Panel 3 includes all non-ECN market makers that are not included in Panel 2.

Panel 1: All Market Maker Displayed Depth

	Day				
	-2	-1	0	1	2
High	-0.006	0.002	-0.034	-0.010	0.004
4	0.005	0.005	0.014	-0.004	-0.007
3	-0.001	-0.009	-0.010	-0.002	-0.004
2	0.003	0.005	-0.004	-0.006	-0.001
Low	0.005	0.003	0.028	0.004	0.004
H-L	-0.011	0.000	-0.063	-0.014	0.000

Panel 2: Investment Bank and Wirehouse Displayed Depth

	Day				
	-2	-1	0	1	2
High	0.000	0.008	-0.023	-0.007	-0.009
4	-0.001	-0.004	-0.025	0.000	0.002
3	-0.004	0.003	0.009	-0.011	-0.001
2	0.003	0.005	0.021	-0.002	0.004
Low	0.008	-0.006	0.013	0.002	-0.002
H-L	-0.008	0.013[a]	-0.036	-0.009	-0.007

a - Significant at 11%

Panel 3: Other Market Makers Displayed Depth

	Day				
	-2	-1	0	1	2
High	-0.006	-0.001	-0.041	-0.007	0.002
4	0.005	0.006	0.011	-0.004	-0.001
3	0.002	-0.006	0.000	-0.005	-0.011
2	0.001	0.002	-0.005	-0.008	0.002
Low	0.006	0.005	0.030	0.008	0.003
H-L	-0.012	-0.005	-0.070	-0.015	0.000

Table X

Returns for Portfolios Classified by Reserve Bid-Offer Depth Imbalances on Earnings Release Days

Nasdaq 100 stocks are assigned to five portfolios based on their bid-offer depth imbalance on the first trading day after the release of earnings news. The imbalance measure is (bid depth - offer depth)/(bid depth + offer depth), where depth is within one cent of the NBBO and is time-weighted throughout the trading day. Each daily return is in excess of the Nasdaq 100 return. This table reports the time-series average return of those portfolios, expressed in percent per day. The final row (H-L) is the difference between the "high" portfolio (with the stocks with the highest bid imbalances) and the "low" portfolio (with the stocks with the highest ask imbalances.) Day zero is the first trading day after earnings are released - the following day when earnings are announced after the market has closed.

A * indicates statistical significance at the 5% level. The test is a one-sided test of the hypothesis that the excess returns of the "high" portfolio stocks have a greater mean than the distribution of returns of "low" portfolio stocks; the test is a Wilcoxon signed rank test. Panel 1 includes all non-ECN market makers. Panel 2 is only Investment Banks and Wirehouses. Panel 3 includes all non-ECN market makers that are not included in Panel 2.

Panel 1: All Market Maker Reserve Depth

	Day				
	-2	-1	0	1	2
High	0.002	0.002	0.003	-0.005	-0.004
4	0.000	0.003	0.013	-0.009	0.002
3	0.007	0.001	-0.007	-0.001	0.001
2	-0.002	0.001	0.010	-0.001	0.000
Low	-0.001	0.000	-0.024	0.000	-0.004
H-L	0.003[a]	0.002	0.027[b]	-0.004	0.000

a - Significant at 9% b - Significant at 12%

Panel 2: Investment Bank and Wirehouse Reserve Depth

	Day				
	-2	-1	0	1	2
High	0.004	0.012	0.006	-0.006	-0.003
4	-0.002	-0.006	0.025	-0.006	-0.007
3	0.001	0.005	-0.023	-0.007	0.013
2	-0.003	-0.001	0.011	0.001	-0.006
Low	0.006	-0.003	-0.025	0.001	-0.002
H-L	-0.002	0.015	0.032[c]	-0.007	-0.001

c - Significant at 11%

Panel 3: Other Market Makers Reserve Depth

	Day				
	-2	-1	0	1	2
High	-0.012	-0.010	-0.001	-0.006	0.002
4	0.005	0.002	-0.006	0.007	-0.010
3	0.009	0.011	-0.002	-0.009	0.009
2	-0.001	-0.009	0.006	-0.008	-0.003
Low	0.007	0.013	-0.001	0.000	-0.004
H-L	-0.020	-0.023	0.000	-0.006	0.006

Fig 1: QQQ Price: May-July 2001

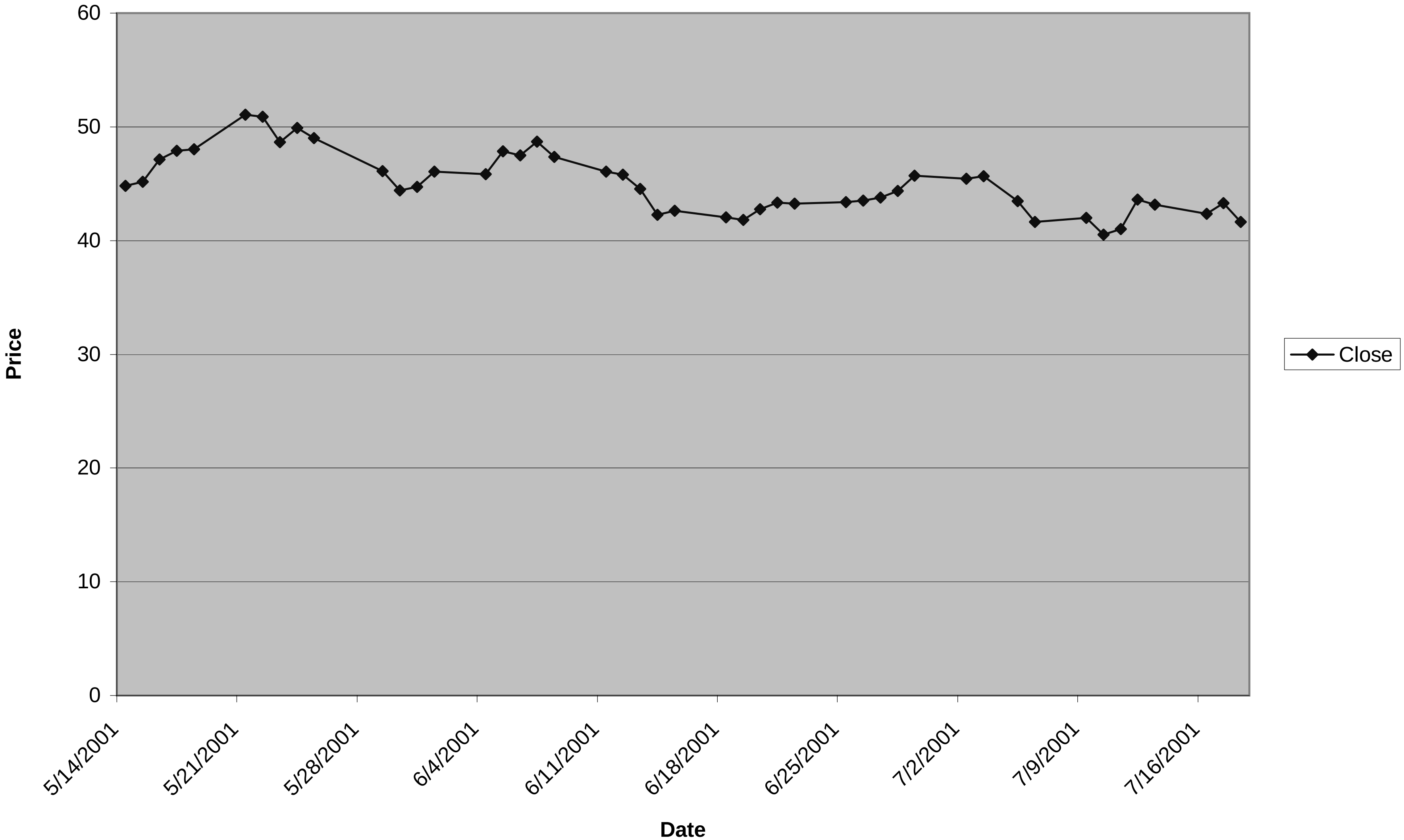

Fig 2: QQQ Price: Mar-May 2002