To the Graduate Council:

I am submitting herewith a dissertation written by Timothy Shawn Strother entitled "Alternative Trading Systems' Impacts on Depth and Informed Trading." I have examined the final paper copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Business Administration.

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ALTERNATIVE TRADING SYSTEMS' IMPACTS ON DEPTH AND INFORMED TRADING

A Dissertation
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Doctor of Philosophy
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Abstract

This study investigates the impact of Alternative Trading Systems (ATS) on depth and the probability of informed trading (PIN). The probability of informed trading and VNET, a metric of depth that determines the net directional volume necessary to induce a price change or return, are estimated for volume-matched samples of New York Stock Exchange (NYSE) and Nasdaq listed firms. Trade and quote data are obtained for two time periods before, and two time periods following, the introduction of trading in decimals on January 29,2001 and April 19, 2001 for the NYSE and Nasdaq, respectively. The data are used to estimate VNET and the probability of informed trading through time for the NYSE and Nasdaq matched portfolios, separating the impact of decimalization on VNET and the probability of informed trading. Estimates of the immediate effect of decimalization on market depth show VNET decreased on the NYSE from pre-decimalization 2001 to post-decimalization 2001. However, decimalization caused no immediate impact on depth on the Nasdaq. Over the year following decimalization, VNET increased on the Nasdaq, but decreased on the NYSE.

The impact of ATS on depth for Nasdaq listed companies has been significant. Higher proportions of quote activity through ECNs are related to increased depth. On the other hand, higher proportions of trading through SelectNet are related to decreased depth and increased spreads.

I find a positive relationship exists between the probability of informed trading and the proportion of trades from SOES and SelectNet, and a negative relationship with ECN quotation activity. Therefore, informed traders' decisions of order execution venue are partially determined by differences in trading protocol between ECNs, SOES, and SelectNet.

Estimates of the probability of informed trading for matched portfolios of NYSE and Nasdaq listed companies suggest that adverse selection costs are lower on the NYSE.

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Introduction

The goal of this work is to investigate the impact of Alternative Trading Systems (ATS) on depth and informed trading in the U.S. equity markets. Additionally, the long-term effects of moving trading from fractions to decimals are analyzed. Using intra-day trade and quote data from four two-week periods between 1999 and 2002, an investigation of the long-term contribution of ATS relative to dealers is undertaken. The results of this investigation will help policy markers determine if recent changes to quotation and trading systems have had the desired results.

Regulatory and structural changes to the NYSE and Nasdaq have important implications for traders. The move to trade stocks in decimals was undertaken with the expectation that lower trading costs should result from a narrowing of inside bid-ask spreads. However, inside bid-ask spreads are an incomplete measure of trade execution costs since they do not incorporate other important aspects of liquidity. In particular, bid-ask spreads do not provide any information about how elastic stock prices are with respect to order flow. That is, inside spreads do not provide any information about the number of shares that must be traded to cause a specific price move or return. Therefore, a decrease in bid-ask spreads is not sufficient to conclude that decimalization has caused an increase in liquidity. Consequently, policy makers should consider the impact of trading in decimals on both inside spreads and depth before drawing conclusions about the impact on market liquidity and transactions costs.

The evolution of the securities markets in the United States has continued under the general premise that the introduction of new trading rules and mechanisms will ensure that U.S. markets remain competitive in the international arena by reducing investors' trading costs and making stock prices easier to understand. However, the rate of change in these rules and trading mechanisms has been so great that financial economists have not had sufficient time to evaluate the effects of these changes before new changes confound prior events. For example, although only a few studies have investigated the impacts of the increasing proportion of trading through Alternative Trading Systems as a result of the 1997 Order Handling Rules (OHR), the Nasdaq moved from quoting in fractions to quoting in decimals during 2001. Without in-depth analysis, potential negative effects of the Order Handling Rules can go overlooked.

Anecdotal evidence of unanticipated negative effects of the Order Handling Rules has already been identified. One issue relates to the SEC Division of Market Regulation's interpretation of the Limit Order Display Rule. The Division of Market Regulation interprets the Limit Order Display Rule to say that exchange specialists or OTC market makers are not required to immediately display a customer limit order that would lock or cross the market. Gerald Putnam, Chairman and Chief Executive Officer of Archipelago Holdings, LLC, has acknowledged a practice whereby Electronic Communication Networks (ECNs) do not provide Best Price Routing to orders that would lock or cross the market. ECNs accomplish this by suppressing display of the Best Priced Orders in Nasdaq, while continuing to display these orders in a proprietary quote feed. Traders refer to these suppressed orders as "Greenies". The result is investors do not always see the best priced order.

This is not to suggest that we discontinue the pursuit of improvements in trading, but rather, to highlight the rapid pace of development in U.S. markets and our lack of knowledge about the contribution of ATS to market quality. ATS such as Electronic

Communication Networks have grown from fledgling secondary trading venues to primary trading avenues. For instance, the ECN named Island claimed an overall Nasdaq share of 16.2% by trades and 7.6% by volume for June 2001.[1] Although Conrad, Johnson, and Wahal (2001) document substantial lower realized execution costs on external crossing systems and Electronic Communication Networks (ECNs), and Huang (2002) shows that ECNs post informative and timely quotes, little else is known. Therefore, it is important to policy makers and market participants to investigate and understand how both regulatory and technological changes are affecting market quality. It is the goal of this work to analyze the effects of Alternative Trading Systems and decimal trading on market quality across two dimensions; depth and informed trading.

The remainder of this document proceeds as follows. Chapter 1 discusses regulatory changes to the financial markets and the development of Nasdaq. Chapter 2 introduces market depth and the related methodology. Chapter 3 provides empirical estimates of market depth. Chapter 4 introduces informed trading and details informed trading methodology. Chapter 5 presents the empirical results and analysis of the probability of informed trading. Chapter 6 offers a two stage least squares regression approach to model depth, informed trading and inside spreads.

[1] These data are available at the Nasdaq website, http://www.marketdata.nasdaq.com/mr_outline.asp.

Chapter 1 Nasdaq Development and Regulatory History

Financial markets do not develop without externalities. For example, LaPorta Lopez-de-Silanes, Shleifer and Vishny (1996) show that legal underpinnings in different countries affect corporate governance issues such as a shareholder rights. Furthermore, they find a link between investor rights and capital market development. Similarly, policy decisions regarding investor protections and trading protocol affect the development of trading venues. Consequently, an understanding of regulatory issues is necessary to appreciate why and how Alternative Trading Systems (ATS) have come into existence. The goal of this chapter is to detail regulatory changes that have affected trading system development.

Since its creation in 1971, the Nasdaq has grown to become the second-most active equity market in the world. The period between 1993 and 2000 showed large increases in average daily trading volume and quotation message traffic. For example, over the period 1993-1999, average daily trading volume increased from 300 million to almost 1 billion shares. Similarly, from September 1999 to April 2000, average daily volume jumped from 1 billion to 1.8 billion shares. In parallel, quotation message traffic increased by 1,120 percent between January 1997 and April 2000. Nasdaq literature states that Nasdaq trading technology is "unsurpassed in reliability, capacity, and accessibility", driving its growth and success.[2]

While policy makers actively deregulated industries such as the utilities industry during the 1990s, regulators did not pursue the same policy for securities markets. In fact, it is arguable that the regulatory introductions of the 1990s were the most significant

[2]Nasdaq SuperMontage Release 1.0: Functional Description, Version 1.0

since the Depression Era acts such as the Securities Act of 1933 and Securities Exchange Act of 1934.

The regulatory changes of the 1990s were driven by the finding by Christie and Schultz (1994) that dealers implicitly collude to maintain wide bid/ask spreads resulting in higher trading costs for investors. Consequently, the development of Alternative Trading Systems has been a function not only of necessity to increase market efficiency but also to satisfy increasing regulatory initiatives.

The following section details quotation, order routing, and trading system development on the Nasdaq market, from the first Nasdaq order routing system to current proposed systems. Regulatory initiatives affecting trading system development are also discussed.

1A. A Brief History

The Nasdaq Stock Market has undergone significant technological advances since the early 1980's. Some developments have been the result of technological innovation needed to satisfy market demands while others have resulted from system failures due to market stress. The more important of Nasdaq's systems include the Small Order Execution System (SOES), SelectNet, the Nasdaq National Market Execution System (NNMS), and the Computer Assisted Execution System /Intermarket Trading System (CAES/ITS).

1A1. The Nasdaq National Market System, SOES, and SelectNet

Smith, Selway, and McCormick (1998) provide a thorough examination of the history and operation of the Nasdaq Stock Market up until 1998. An important early change in the Nasdaq system was the introduction of timely transaction reporting with the establishment of the Nasdaq National Market System (Nasdaq/NMS) in 1982. The Nasdaq/NMS was originally comprised of the 40 most active Nasdaq securities. The NMS required the volume and price of each trade to be reported within 90 seconds of execution. Non-NMS (i.e. regular Nasdaq securities) continued to report trade executions at the end of the day until mid-June 1992. In 1993, Nasdaq/NMS was renamed the Nasdaq National Market (NNM), and non-NMS securities were named Nasdaq SmallCap securities.

Additional significant developments in the Nasdaq market involved the establishment of order routing, trading, and reporting systems.[3] The Small Order Execution System (SOES) was the Nasdaq's first order routing and trading system and began trading in December 1984. Trading was limited to the automated execution of agency orders, orders executed on the behalf of customers, in Nasdaq/NMS securities with size of 500 shares or less. Market makers could only have orders executed against their quotes. SOES trading was extended to all Nasdaq securities with trade size limited to 1,000 shares or less in 1985, with a minimum size of one round lot.[4] Market maker participation in SOES was voluntary until the market crash of 1987 forced reforms

[3] Nasdaq was originally designed primarily as a quote-dissemination system. Today, the Nasdaq quotation management system " collects and displays quotations of registered market makers and Electronic Communication Networks (ECNs) that are members of the NASD, " collectively known as Nasdaq market participants. "By agreement, Nasdaq also collects and display quotations in Nasdaq securities from Unlisted Trading Privileges (UTP) exchanges."
[4] Minimum SOES tier size requirements were not introduced until 1990.

resulting in mandatory market maker participation in NMS securities. Mandatory market maker participation requires market makers to execute orders submitted to SOES at the inside bid-ask spread. This change created a venue for individual investors to immediately execute orders ahead of orders placed through other trading systems.[5]

Further changes to SOES occurred with the implementation of the 1997 Order Handling Rules (OHR). The Order Handling Rules, discussed later, set minimum quoted size equal to the size of the maximum SOES order size. SOES tier sizes, the maximum number of shares for an order submitted to SOES, are stock specific and determined by a security's average daily trading volume, share price, and number of market makers. As of July 20th, 1998, the sizes for NNM stocks were 1,000, 500, and 200 shares. However, SOES participation was voluntary for Nasdaq SmallCap stocks with tier sizes of 100 or 500 shares.

SelectNet "is an electronic screen-based order routing system that allows market participants to negotiate securities transactions in Nasdaq securities through computer communications."[6] SelectNet began in 1988 as the Order Confirmation Transaction service (OCT). OCT was designed to overcome the limitations of telephone contact. It was established as an electronic order delivery system that automatically locked-in accepted orders for trade reporting and clearing.

In 1990, OCT was improved to allow back-and-fourth negotiation between senders and recipients of orders. Furthermore, the feature enabling participants to

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[5] Individual investors that exploit the differences in trading efficiency or protocol across trading venues are often called SOES day traders.
[6] See NASD Notice To Members 00-30.

broadcast orders to all market makers in a stock was introduced. Also, OCT was renamed SelectNet.

Smith, Selway, and McCormick (1998) discuss the features and requirements of SelectNet as of August 24, 1998. SelectNet participants can negotiate a larger size or better price relative to the current inside quote. Additionally, SelectNet enables participants to limit the amount of time an order will be in effect from 3 to 99 minutes. This system also allows the specification of day orders and minimum acceptable share amounts. Participants may counter, accept, decline, or price improve SelectNet orders. Prior to July 10, 2000, SelectNet allowed subscribers to preference or direct orders to pre-specified market makers or to broadcast orders to all market participants. NASD Notice to Members 00-30 notes that although SelectNet is an order delivery service rather than an order execution service, orders preferenced to a market maker at the market maker's displayed quotes create the liability for that market maker to execute the transaction at its quoted price and size.

The 1997 Order Handling Rules (OHR) increased the importance of SelectNet as an order routing mechanism. This resulted from the linkage that SelectNet creates between Nasdaq and Electronic Communication Networks. The OHR introduced the requirement that market makers must make their own best priced quotes posted through an ECN publicly available. The new rules provided two avenues for market makers to meet this requirement. First, market makers could improve the prices of their quotes.

Second, they could send the better priced orders to an ECN that will disseminate the orders to the public quotation system which is equally accessible by brokers/dealers.[7]

1A2. The Nasdaq National Market Execution System (NNMS)

The evolution of the Nasdaq market continued with the SEC's approval of rule changes on January 14, 2000. These rule changes established a new trading platform for Nasdaq National Market (NNM) securities and amended the rules governing SelectNet.

The new rules reestablished SelectNet as a non-liability order delivery and negotiation system for NNM Securities with the goal of eliminating the potential for "dual liability" for market makers. Dual liability is the obligation of market makers to execute multiple orders submitted through different trading systems, where those orders should be satisfied by the market maker's posted quoted size. It is believed that the subjection of market makers to unintended double liability for orders that reached their quotes at the same time through two trading systems (e.g. SOES and SelectNet) resulted in a decrease in incentives for market makers to commit capital. Consequently, quotation sizes and liquidity were lower than equilibria levels for single liability order systems.

The NNMS eliminated the use of SelectNet to preference orders to market makers in NNM Securities unless the orders are at least 100 shares in excess of the receiving market makers' quoted size. This requirement is known as the over-sized order requirement and is also extended to orders directed to ECNs that register for automatic execution against their quotes in the NNMS. In addition to the size requirement of the

[7] SelectNet will continue to perform this function for ECNs that choose not to take automatic execution against their quotes through the Nasdaq National Market Execution System (NNMS) after the implementation of SuperSOES. SuperSOES will be discussed later.

over-sized order rule, the orders must also be designated as "All-or-None" (AON) or "Minimum Acceptable Quantity" (MAQ) orders. SelectNet orders that meet the over-size requirements can either be executed or negotiated by the recipient.

The Nasdaq National Market Execution System substantially enhanced the trading of NNM securities through SOES. The enhancements include: (1) raising the maximum order size for NNM securities to 9900 shares; (2) enabling the entrance and automatic execution of agency and proprietary orders in NNM securities (including market makers); (3) reducing the minimum amount of time until the system will deliver another order to a given market maker to 5 seconds from the prior execution (previously 17 seconds); (4) creating automatic interaction of NNM orders with market makers' displayed size and reserve size; and (5) eliminating the "No Decrementation" option and order preferencing in SOES. In general, these rule changes were expected to reduce the problem of dual liability, promote access of the entire quoted depth to all market participants, and increase the speed of executions.

One of the features of NNMS is the reserve size. The reserve size is the new quote size to which a posted quote will be set once the quoted size is decremented to zero. Although the reserve size is not displayed in Nasdaq, it is automatically available once all displayed interest is exhausted. Furthermore, the system will execute all displayed quotes at the same price level before accessing the reserve size, thereby maintaining time priority. NNMS participants using the reserve size function must quote (display) a minimum of 1000 shares.

The NNMS is also associated with new quote refresh rules and categories of ECNs. First, when a market maker's quote is refreshed to a different size or price level than previously quoted, additional orders will not be directed to that market maker for five seconds following that refresh. Second, ECNs can choose to be either a Full-Participant or Order-Entry ECNs (OE ECNs). Full-Participant ECNs provide automatic execution against their quotes for orders entered into NNMS, while Order-Entry ECNs do not. However, market participants can access Order-Entry ECN quotes through SelectNet, with preferenced messages up to 999,999 shares. Note that the oversized order requirement for preferenced SelectNet orders is not applicable to receiving Order-Entry ECNs, but is applicable to sending Order-Entry ECNs.

As of the approval date for NNMS, Nasdaq was working with Unlisted Trading Privileges (UTP) Exchanges to integrate them into the automatic execution functionality of NNMS. However, since the UTP exchanges were not integrated, SelectNet remained their primary linkage with Nasdaq allowing the receipt and delivery of preferenced SelectNet liability orders. Consequently, market makers still face the problem of dual liability for UTP eligible securities.

Effective February 14, 2000, the Intermarket Trading System (ITS) plan was amended to expand the Computer Assisted Execution System (CAES)/ITS linkage to all exchange-listed securities, including non-Rule19c-3 securities.[8] Expansion of the linkage was expected to "increase market efficiency and transparency, reduced trade-throughs, and level the playing field between Third Market firms and exchanges; decrease market fragmentation and produce long-term benefits to the National Market System (NMS); increase the liquidity and competitiveness of the securities markets; and increase the opportunity for investors to obtain the best price available in all markets for orders in

[8] See Nasdaq Head Trader Alert #2000-05. Detail of the ITS will be presented later.

exchange-listed securities." This was an important step in addressing Section 11A(a)(2) of the Securities Exchange Act of 1934.

Section 11A(a)(2) under the Securities Exchange Act of 1934 ("the Act") was adopted by the Securities Acts Amendments of 1975. Section 11A(a)(2) directs the SEC to use its authority to facilitate the establishment of a national market system for securities in accordance with the Congressional findings and objectives set forth in Section 11A(a)(1) of the Act. SEC Release No. 34-42212, File No. 4-208 states that "among those findings and objectives is the linking of all markets for qualified securities through communication and data processing facilities."

Trading in UTP eligible securities was further altered on August 29, 2000 when the SEC Release No. 34-43217 amended Rule 12f-2 under the Securities Exchange Act of 1934 to permit national securities exchanges to begin trading in IPOs immediately after the first trade in the security is reported by the listing Exchange to the Consolidated tape. Previously, Unlisted Trading Privileges became available to an IPO security listed on another exchange after the first day of trading on the listing Exchange. The amendment became effective November 6, 2000.

The introduction of the Nasdaq National Market Execution System did not change the trading rule for automatic execution of Nasdaq SmallCap securities. Consequently, the over-sized order requirement does not apply to Nasdaq SmallCap issues. Although participation in automatic execution for Nasdaq SmallCap securities remains voluntary, market makers that receive SelectNet orders that match the market maker's quoted price and size must honor those orders for Nasdaq SmallCap issues.

1A3. Nasdaq SuperMontage

On January 19, 2001, the SEC approved the establishment of the Nasdaq Order Display Facility (NODF) and Order Collector Facility (OCF). Modifications to the Nasdaq National Market System were also approved.[9] Collectively, the changes are known as the SuperMontage proposal. The SuperMontage proposal was designed to alter Nasdaq's systems in three main areas: (1) quote/order collection; (2) quote/order display; and (3) execution services. Perhaps the most significant goal of the SuperMontage proposal is to increase the amount of trading interest displayed to the market, thereby increasing transparency and enhancing the price discovery process.

The acceptance of the SuperMontage proposal by the SEC was conditioned on several stipulations. The SEC stated "The commission has considered the SuperMontage proposal in the context of increased demand for information about trading interest, increased competition among execution service providers, and changes in Nasdaq's ownership structure. The Exchange Act requires the commission to approve the proposed rule changes if it finds that the changes are consistent with the requirements of the Exchange Act applicable to the National Association of Securities Dealers (NASD).[10] In this context, including Nasdaq's demutualization, application for registration as an exchange, and impending full separation of the NASD and Nasdaq, and for the reasons discussed in this release, the Commission finds that the proposed rule changes are consistent with the requirements of the Exchange Act applicable to the NASD and therefore approves the proposed rule changes."[11] This statement identifies the impending

[9] See SEC Release No. 34-43863
[10] The National Association of Securities Dealers owns the Nasdaq.
[11] See SEC Release No. 34-43863

full separation of the NASD and Nasdaq as influencing the decision to accept the SuperMontage proposal.

The Commission's belief that full separation is impending is understandable considering "the NASD board adopted a resolution stating its intent to divest itself of all remaining shares of Nasdaq not subject to outstanding warrants by June 30, 2002, subject to existing contractual and legal arrangements and to the reasonable judgment of NASD management that market conditions permit." While Nasdaq completed the repurchase of the 33,768,895 shares of common stock not subject to outstanding warrants on March 8, 2002, the NASD still owns 43,225,976 shares of common stock underlying the warrants issued by the NASD as part of its restructuring of the ownership in Nasdaq.[12]

Furthermore, the NASD owns all of the outstanding shares of Series A and B Nasdaq preferred stock. While Series A shares do not have voting rights, Series B shares entitle the NASD to cast the number of votes that when combined with all other votes that the NASD is entitled to vote by virtue of ownership, proxies or voting trusts, enables the NASD to cast one vote more than one-half of all votes to be cast by stockholders. However, if Nasdaq obtains exchange registration, Series B preferred shares will automatically lose their voting rights and be redeemed by Nasdaq. Therefore, until the Nasdaq obtains exchange registration, the "impending full separation of the NASD and Nasdaq " will go unfulfilled even though the trading platform SuperMontage will be operable.

Prior to approval of the SuperMontage proposal, commenting participants expressed concern about conflicts of interest with respect to the NASD's ownership of

[12] See Nasdaq March 2002 10-Q.

Nasdaq. For example, Archipelago LLC, one of the original four ECNs approved in January 1997 by the Commission comments, "Nasdaq's entry into the execution business presents severe conflicts of interest with respect to NASD's ownership of Nasdaq, its ownership of NASDR, and Nasdaq's role as the SIP (securities information processor)."[13] In particular, Archipelago was concerned that Nasdaq has a competitive advantage as the sole securities information processor by controlling and studying the Order Audit Trail System ("OATS") in which all NASD members are compelled to participate.[14]

Market participants are responding to changes in Nasdaq's execution and reporting systems by creating alliances with regional exchanges seeking to establish themselves as national securities exchanges. For instance, on October 25, 2001, the SEC approved a proposal by the Pacific Exchange (PCX) to establish the Archipelago Exchange ("ArcaEx ".) ArcaEx is the first fully electronic National Securities Exchange for trading equity securities since 1976. On March 22, 2002, the Archipelago Exchange began trading 27 Pacific Exchange exclusively listed shares. Phase-in schedules for listed stocks occur between July 1st and July 19, 2002. Trading in certain Nasdaq stocks through ArcaEx began February 14, 2003.

The SuperMontage trading platform should eliminate some drawbacks to Nasdaq's current quotation and trading system. Prior to SuperMontage, each Nasdaq quoting market participant and UTP Exchange was permitted to enter a single quotation into the system at any one time. The quotation may reflect customer limit orders, the

[13] The National Association of Securities Dealers Regulation (NASDR) is a subsidiary of the NASD that regulates the activities of the Nasdaq market and brokers/dealers.
[14] See Archipelago comments in response to file number SR-NASD-99-53, September 15, 2000.

Nasdaq Quoting Market Participant's or UTP Exchange's proprietary trading interest, or both. Market makers are subject to double liability exposure because SOES and SelectNet systems are not currently integrated. Although SelectNet is an order delivery service rather than an execution service, orders delivered to a market maker or ECN at its displayed quotation creates an obligation to execute the order at the quoted price and size."[15] Prior to SuperMontage, Nasdaq quotation systems displayed the best bid and offer of a Nasdaq Quoting Market Participant or UTP Exchange.[16] However, market participants prefer to be able to observe trading interest outside of a Nasdaq Quoting Market Participant's or UTP exchanges' best bid and offer. Consequently, the SuperMontage is designed to modify Nasdaq systems in three principal areas: (1) quote/order collection; (2) quote/order display; and (3) execution services.

SuperMontage will increase the ability of UTP exchanges and Nasdaq Quoting Market Participants to present orders and quotes in the Nasdaq market. It will allow, but not force, Nasdaq Quoting Market Participants and UTP Exchanges to enter multiple quotes and/or orders at varying or the same prices. Although market makers will be required to maintain a two-sided attributable (i.e. not anonymous) quote/order complying with Commission and NASD rules, SuperMontage will enable Nasdaq Quoting Market Participants to submit non-attributable (i.e. anonymous) quotes/orders. UTP Exchanges can submit non-attributable agency quotes/orders, but principal orders must be attributable.[17]

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[15] See Firm Quote Role.
[16] Release No.34-43863 notes that the large majority of orders are executed outside Nasdaq's order delivery and execution systems via direct links, including dedicated line and telephone, among the ECNs, UTP exchanges, and market makers.
[17] Principal orders are orders by a broker/dealer when buying or selling for its' own account.

Additional information will be gathered from SuperMontage through the voluntary submission of additional quotes/orders from market participants in two ways. First, best-priced non-attributable quotes /orders from all participants will be aggregated into one buy and one sell price, both named "SIZE." Additionally, the best-priced attributable quotes/orders of each Nasdaq Quoting Market Participant and UTP Exchange will be displayed. The second display modification is the presentation of the three best-priced quotes/orders through the Nasdaq Order Display Facility (NODF). The three best-priced quotes/orders come from the aggregation of all quotes/orders, both attributable and non-attributable. Information from the second display modification will be provided to market data vendors for distribution.

Changes to Nasdaq's execution services involve the replacement of SOES and SelectNet with two new processes: a non-directed order process and a directed order process.

The non-directed order process will be the default execution process for marketable orders. Marketable non-directed orders will be matched and either executed against, or delivered to, the highest ranked opposite side quotes/orders of the Nasdaq Quoting Market Participants and UTP Exchanges on a liability basis. Market makers must auto execute these orders while UTP Exchanges and ECNs can choose automatic execution or delivery.

The non-directed order process will rank quotes /orders of Nasdaq Quoting Market Participants and UTP Exchanges according to one of three pre-specified algorithms: (1) price/time priority, which is the default algorithm, (2) price/size/time priority, or (3) price/time priority that accounts for ECN fees. Order preferencing by a

Nasdaq participant is allowed if the receiving Nasdaq Quoting Market Participant or UTP Exchange is at the best bid-offer.

The directed order process allows Nasdaq participants to send orders to specific UTP Exchanges or Nasdaq Quoting Market Participants. An order is deemed a liability order only if it matches the posted quote/order of the recipient. The receipt of directed liability orders causes the risk of double liability. The receipt of directed liability orders through the Order Control Facility is voluntary for UTP Exchanges and Nasdaq Quoting Market Participants.

Although the Commission notes that controversial issues still remain regarding SuperMontage, it concluded that the Nasdaq's agreement to disseminate the details of all attributable quotes/orders in the three best price levels on either side of the market resolves significant controversy. Furthermore, the Commission states "The result will be that all quote/order details will be generally available at the best price levels, except those quotes/orders that are submitted on an anonymous basis. The commission believes that this additional information will be valuable to competitors that may offer execution services complementary to, or in competition with, Nasdaq SuperMontage services. . ."

The implementation of SuperMontage is expected to enhance quoting/trading for Nasdaq Quoting Market Participants and UTP Exchanges. It will be left for researchers to determine if increases in liquidity result from the reduction in dual liability. Furthermore, it is unclear what effect the apparent increased ability to quote/trade anonymously will have on adverse selection costs and liquidity.[18]

[18] For more details on SuperMontage , see Commission Release No.34-43863.

1A4. Changes to the Intermarket Trading System

The Intermarket Trading System (ITS) arose from the Securities Acts Amendments of 1975 and seeks to connect competing exchanges or markets, enabling investors to execute trades at the best prices across all markets. Section 11A(a)(2) of the Securities Acts Amendments of 1975 directs the Commission to facilitate the establishment of a National Market System (NMS). In March 1978, several exchanges submitted a plan to the Commission to operate "an Intermarket Communications Linkage," which later became known as the ITS Plan. The American Stock Exchange, Boston Stock Exchange, Pacific Exchange, and the Philadelphia Stock Exchange were involved in the creation of the plan. Currently, the Chicago Board Options Exchange, Chicago Stock Exchange, Cincinnati Stock Exchange, and NASD are also ITS participants.

The NYSE sought to be excluded from the ITS. On April 26th 1979, the NYSE proposed Rule19c-3 to preclude "exchange off-board trading restriction from applying to securities listed after April 26th 1979."[19] During hearings for the rule, the NASD introduced plans to upgrade its order routing system enabling firms to obtain automatic executions against quotations of Third market makers in listed securities.[20] Rule19c-3 was adopted on June 11, 1980 with the ITS Plan permanently approved on January 27, 1983.

[19] See Exchange Act Release No. 15769.
[20] The upgraded order routing system is known as the Computer Assisted Execution System (CAES).

Although the expansion of the ITS/CAES linkage to include non-Rule19c-3 Securities was considered as early as November 12, 1991, because of disagreement among the ITS participants a supportable proposal was not introduced until the Commission proposed its own initiative in July 1998.[21]

Effective February 14, 2000, the Commission implemented amendments to the Intermarket Trading System. The amendments expanded the ITS/Computer Assisted Execution System linkage to all listed securities, including non-Rule19c-3 securities. Although all securities listed on the New York Stock Exchange, American Stock Exchange, and Nasdaq National Market are eligible for UTP trading by other exchanges or markets, there is a limit to the number of Nasdaq National Market issues that an exchange can trade at a single point in time.[22] The limit is currently 1000 issues with the Chicago Stock Exchange being the only active UTP participant.

In conclusion, the commission expanded the ITS to include non-Rule19c-3 securities believing that the expansion would, "increase market efficiency and transparency, reduced trade-throughs, and level the playing field between the third market firms and exchanges; decrease market fragmentation and produce long-term benefits to the National Market System; increase the liquidity and competitiveness of the securities markets; and increase the opportunity for investors to obtain the best price available in all markets for orders in exchange-listed securities."[23]

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[21] Although the Commission solicited comment on the ITS/CAES expansion in the proposed release of the Order Handling Rules in 1995, the expansion was not included in the adoption releaseed.
[22] See Chapter 2 of the revised January 2001 Nasdaq Trader Manual.
[23] Nasdaq memo dated January 28, 2000, Re: expansion of the Intermarket Trading System to include non-Rule19c-3 Securities. See the Nasdaq Trader Manual, Chapter 11 to obtain information on registration as a Consolidated Quotation Service Market Maker and quotation and trading policies as of October 2000.

1A5. SelectNet Modifications

In July 2001, Nasdaq begin implementing further changes to SOES and SelectNet. The changes are designed to reduce dual liability and reestablish SelectNet as an order delivery and negotiation system for NNM securities. The changes are also designed to allow market makers to use the automatic execution system for transactions for their own accounts. Additionally, the upgrades enable system interaction with a market makers reserve size. Overall, an increase in trading efficiency is expected.[24]

1B. 1997 Order Handling Rules (OHR)

On September 6th 1996, the Securities and Exchange Commission adopted new rules designed to address increasing concerns about the handling of customer orders. The Order Handling Rules (OHR) were written to give all investors equal access to the best-priced orders. It mandates that investor limit orders that improve the inside market must be displayed in the quote montage. In particular, the Commission adopted Rule Ac1-4, the Display Rule, and Rule 11Ac1-1, the Quote Rule. The Commission expected these rules to help the development of an efficient, competitive and transparent National Market System in which all market participants could achieve best execution of their orders.[25]

The Display Rule "requires OTC market makers and specialists to display the price and full-size of customer limit orders when these orders represent buying and

[24] See the SuperSoes/SelectNet Modifications Fact Sheet Revised June 19, 2001.
[25] See 17 CFR part 40, Release No.34-37619A, File No. S7-30-95.

selling interest that is at a better price than a specialist's or OTC market maker's public quote. OTC market makers and specialists also must increase the size of the quote for a particular security to reflect a limit order of greater than de minimus size when the limit order is priced equal to the specialist's or OTC market maker's disseminated quote, and that quote is equal to the national best bid or offer." However, when a specialist or market maker sends a limit order to an exchange, registered national securities association system or Electronic Communications Network that complies with the Display Rule, they are exempted from the rule. Thus, market makers can avoid posting a customer's limit order in its own quotes by routing the limit order to an ECN.

The Quote Rule requires the collection and public dissemination of the best bid, best offer, and size for each market quoting any security covered by the Quote Rule. In particular, market makers that elect to quote a Nasdaq National Market security must publish those quotes. Furthermore, the rule requires that quotations be firm with market makers and specialists generally obligated to execute orders at prices that are at least as favorable as their published bid or offer up to the size of their published bid or offer.

The Order Handling Rules added three amendments to the Quote Rule. The first amendment requires an OTC market maker or specialist to make orders placed through an ECN publicly available if the orders price-improve the specialist's or market maker's public quotation. However, if the ECN orders are publicly disseminated and available to other brokers/dealers, then those market makers or specialists are deemed in compliance with the Quote Rule. Consequently, a market maker is not required to reflect a better-priced order in its quotes when the market maker routes the order to an ECN. This display option is known as the ECN display alternative.

The second Quote Rule amendment extends the mandatory Quote Rule to OTC market makers and specialists whose volume exceeds 1% of the aggregate volume over the most recent calendar quarter.

The third Quote Rule amendment extends certain Quote Rule provisions to voluntarily quoted Nasdaq SmallCap securities. Specifically, the firmness obligations that formerly applied only to Nasdaq National Market securities are extended to SmallCap securities.

1C. Regulation for Alternative Trading Systems

On December 2, 1998, the SEC voted to publish two releases to modernize regulations for Alternative Trading Systems (ATS). The commission provided three primary concerns leading to the adoption of the two releases: (1) Alternative Trading Systems are regulated as traditional broker-dealers. Consequently, prior regulations failed to provide access to best prices, audit trail, adequate surveillance, or adequate prevention of system outages to investors; (2) regulatory requirements for registered exchanges and the NASD hinder their ability to compete with Alternative Trading Systems. Specifically, the NASD and registered exchanges must solicit public comment and receive SEC approval prior to changing their rules; and (3) registered exchanges or exchanges considering registration may wish to operate as a for-profit organization rather than a not-for-profit, member-owned corporation.

The December 2, 1998 releases address these issues by: (1) creating a new regulatory framework for Alternative Trading Systems that enhances investor protection and incorporates the systems into the national market system; (2) allowing registered exchanges and the NASD to postpone seeking SEC approval of low-volume pilot trading systems for two years, and to trade new derivative securities products without prior commission approval if listing standards are in place; and (3) allowing registered exchanges to operate as for-profit businesses.

The new regulatory framework for Alternative Trading Systems allows their registration as broker/dealers. Although registration as broker/dealers was allowed prior to Regulation ATS, additional requirements are imposed on those choosing to register as broker/dealers. First, when an Alternative Trading System is responsible for 5% or more of the trading volume on an exchange or Nasdaq listed security, the ATS must link with a registered exchange or the NASD and publicly display its best priced orders. Furthermore, those quotes must be executable by the registered exchanges and the NASD. However, only the orders that participants in an ATS choose to show to two or more participants must be publicly displayed (i.e. reserve sizes are excluded).

For exchange-listed securities, if a system for publicly displaying orders from an ATS to a national securities exchange or association does not exist, then an Alternative Trading System will not be violating Rule 301(b)(3) for failing to post quotes. "Rule 301(b)(3) requires an alternative trading system to provide to a national securities exchange or national securities association, for inclusion in the public quotations system, prices and sizes of its best priced buy and sell orders, that are displayed to more than one person, in each covered security in which the alternative trading system represents 5% or more of the trading volume." [26] Securities became subject to regulation ATS from 1999

[26] See SEC Release No.34-41297.

through 2000.[27] The schedules were determined by ranking all covered securities on Nasdaq, according to their January 1999 volume, into deciles taking an equal number of securities from each decile. Securities listed after January 1999 became subject to the requirements on June 20, 2000.

The second additional requirement is the assurance of certain capacity, integrity, and security standards for an Alternative Trading System with 20% or more of the trading volume of a security.

The last additional requirement is the prohibition of unfair discrimination among investors and brokers/dealers seeking access to an Alternative Trading System with 20% or more of the trading volume of a security.[28]

1D. Decimal Pricing in the U.S. Securities Markets

On January 28, 2000, the Securities and Exchange Commission issued an order directing the exchanges and NASD to submit a decimalization implementation plan.[29] The commission recognized the potential benefits of decimal pricing over fraction-based pricing as early as January 2nd, 1994.[30] In the order, the Commission stated that it believes decimal pricing could benefit investors by enhancing investor comprehension, facilitating globalization of U.S. markets, and potentially reducing transactions costs,

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[27] The phase-in dates were August 23, 1999 for Schedule A securities, September 28, 1999 for Schedule B securities, April 25, 2000 for Schedule C securities, and all other securities by June 20, 2000.
[28] SEC Release No.34-41297 also discusses a technical change to Rule of Practice 202.3(b)(2) regarding the process of applying for registration or exemption of registration as a national security exchange.
[29] Release No.34-42360, File No. 4-430.
[30] Division of Market Regulation, Commission, Market 2000: An Examination of Current Equity Market Developments, January 1994.

depending on the minimum price increment chosen. Consequently, the SEC issued the order pursuant to Section 11A(a)(2) and Section 11A(a)(3).[31]

The implementation of decimalization occurred in a step-wise fashion which differed across exchanges. All stocks were not universally subjected to the new regulations at the same time because some exchanges made the transition to decimal pricing more easily than others. The first group of stocks began trading in decimals on August 28, 2000 and only included companies listed on the New York Stock Exchange (NYSE) and the American Stock Exchange (AMEX). The second group of stocks began trading in decimals on September 25, 2000 and again only included companies listed on the NYSE and AMEX. The third pilot group was comprised only of NYSE stocks and subject to the new rules as of December 4, 2000. Finally, virtually all NYSE and AMEX listed companies began trading in decimals on January 29, 2001.

Nasdaq listed companies were subjected to the new trading rules in three phases. The first group of stocks became subject to trading in decimals on March 12, 2001, the second on March 26, 2001, and all remaining issues on April 9, 2001.[32]

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[31] The first section directs the Commission, having due regard for the public interest, the protection of investors, and the maintenance of fair and orderly markets, to use its authority under the Securities Act of 1934 to facilitate the establishment of a national market system for securities. The second section " gives the commission the ability to authorize or require by order the self-regulatory organizations to act jointly*** in planning, developing, operating, or regulating a national market system."

[32] On July 18, 2001, the Commission issued Release No. 34-44568, File No. S7-14-01, requesting comment on the effects of decimal trading in subpennies.

1E. Other Developments

On February 24, 2000, the Securities and Exchange Commission approved the International Securities Exchange LLC (" ISE ") as a national securities exchange.[33] According to the International Securities Exchange, it is "the first new registered U.S. Securities Exchange in 26 years, first fully electronic options exchange in the United States, and the world's first options marketplace combining electronic trading with auction market principles."[34] Trading began on May 26, 2000. As of July 17, 2002, the International Securities Exchange is the industry volume leader in the 509 issues that it trades and is now the primary market in volume terms for 276 of its issues.[35] Furthermore, the International Security Exchange's market share has risen to 28% for all 509 issues, and to 25.1% in all listed equity options. The 509 issues listed for trading account for more than 90 percent of all equity options volume across all five U.S. options exchanges. Since options trading is outside the scope of this work, a detailed discussion of ISE rules and trading systems is not warranted. However, it should be noted that the trading of options on equities has been shown to affect the quality of the underlying equity market. Consequently, the shift in order flow to the ISE from the other exchanges could impact trading in those underlying securities.

In summary, changes to trading systems and regulations since the introduction of the 1997 Order Handling Rules may affect investors' choice of trading venue. These changes may ultimately impact market depth and the probability of informed trading.

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[33] See Release No.34-42455.
[34] ISE news release, "International Securities Exchange files for registration with the SEC."
[35] ISE news release, "International Securities Exchange trades 150-million contract."

Chapter 2 Changes in Depth

2A. Introduction

While researchers have documented evidence of smaller bid-ask spreads for stocks actively traded through ECNs, other important contributions of Alternative Trading Systems to market depth and liquidity are still to be documented.[36] Similarly, the long-term effects of trading in decimals on market depth and liquidity are unknown. Therefore, the combined effects of increased trading through Alternative Trading Systems and trading in decimals on liquidity are unknown and may have significant implications for both market liquidity and the related trading costs. It is the goal of this chapter to investigate the joint impact of ATS and decimalization on market depth.

Liquidity has been long discussed in the finance literature. Engle and Lange (2001) define liquidity as the ability to transact at low cost. In this context, liquidity is said to decrease as the cost to execute a transaction increases. Consequently, investors are concerned about liquidity because transactions costs reduce performance.

The bid-ask spread is often considered a measure of liquidity since it represents the difference between the price at which an individual investor can buy (the ask price) and sell (the bid price) a given number of shares for a specific stock. However, the bid-ask spread is not a complete measure of liquidity since the quoted inside spread is firm for only a limited, usually relatively small, number of shares. Engle and Lange (2001) refer to the bid-ask spread as a measure of tightness of the market price for low volume trades. Therefore, tightness, or the bid-ask spread, represents just one component of liquidity.

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[36] Strother *et al.* (2003)

The second component of liquidity is depth; the maximum number of shares that can be traded at a given price. Figure 1 depicts a hypothetical market reaction curve, which shows the expected transaction price per share given the desired number of shares to be traded for a specific stock. Tightness is represented as the vertical distance between the prices at which the buy and sell curves intersect the price line. The buy and sell curves look like staircases to reflect the lumpiness of quotation sizes. Depth is the horizontal distance between the price line and the number of shares to be traded. The steeper the market reaction curve, the larger the price impact for a given trade volume. Therefore, steeper market reaction curves reflect lower liquidity and higher transactions costs.

Literature Review

Early microstructure literature argued that individual stock volatility, price, and trading volume are important determinants of liquidity.[37] Chordia, Roll, and Subrahmanyam (2001) state that from an inventory perspective, individual-stock dollar volume should reduce spreads and increase depth; individual-stock volatility should have the opposite effect. When informed traders are the sole possessors of information, asymmetric information should increase both spreads and volatility. Furthermore, if informed traders earn higher profits than uninformed traders, spreads should increase as volatility increases.

Harris (1997) suggests that smaller tick sizes may reduce liquidity. Recall that

[37] See Bentson and Hagerman (1974) and Stoll (1978).

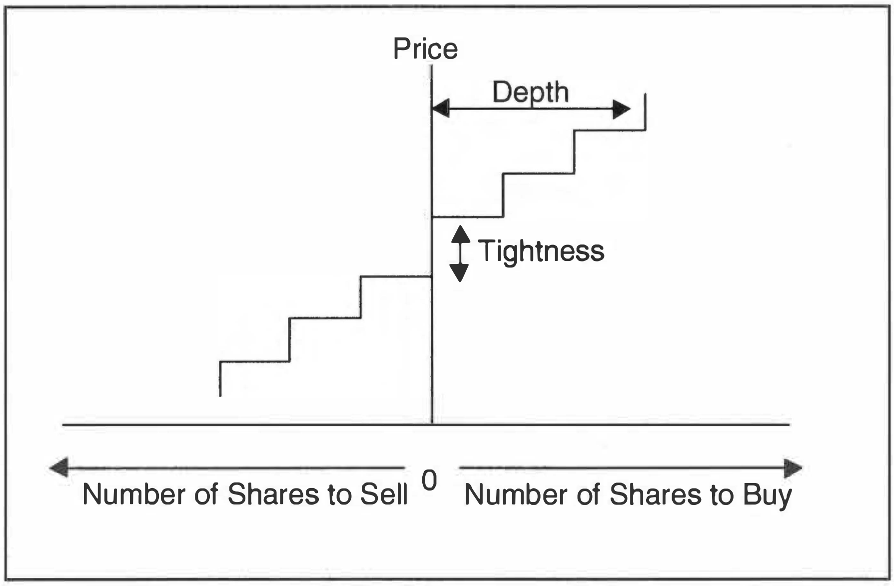

Figure 1. Hypothetical Market Reaction Curve

market makers' revenues are, at least partially, derived from the spread through buying at the bid price and selling at the ask price. Assuming that trading volume does not increase proportionally to the decrease in spreads, market makers expect to earn lower revenues in the presence of tighter spreads. Consequently, it is reasonable to assume that lower returns (i.e. profits) by market makers will induce them to assume less risk.

There are at least two, not necessarily mutually exclusive, ways in which market makers can reduce their risk to adjust for tighter bid-ask spreads. First market makers could reduce expected inventory holding costs by lowering the number of shares they hold. Alternatively, they could decrease their posted obligations to trade (quote size), thereby reducing the magnitude of possible changes in inventory holdings. If they choose to reduce the number of shares they hold, there should be a one-time adjustment in depth at the time of the move to decimalization. Market makers could then keep their quoted size similar to pre-decimalization levels. If market makers choose to reduce their quote sizes, then there should be an unambiguous decrease in depth.

Some foreign exchanges pre-empted the move by U.S. securities markets to quote in decimals. For example, the Toronto Stock Exchange began quoting in decimals in 1995. In general, researchers have found that the change to decimals reduced spreads but did not adversely affect liquidity.[38] On the other hand, reduced spreads attracted more trading interest away from the upstairs market and onto the floor. After the move to decimals, market makers executed more trades less than 1,000 shares in Toronto, but the upstairs market executed fewer trades less than 10,000.[39]

Prior to the move to decimalization, U.S. securities markets reduced tick-sizes from \$ 1/8 to \$ 1/16. Atkinson and Martin (1999) find that the reduction in tick sizes on the NYSE resulted in a smaller spreads and lower depth. However, they find no evidence of increased daily volatility. Furthermore, they find a reduction in trade-to-trade volatility. Bollen and Whaley (1998) show that spreads for low-priced stocks decreased the most on a percentage basis. Smith (1998) and Christie et al. (1999) find that benefits of smaller tick sizes on Nasdaq are similar to those on the NYSE, evidenced by smaller quoted and effective spreads, decreased depth, and insignificant changes in volatility.

Preliminary research investigates the impact of trading in decimals on the New York Stock Exchange. Chakravarty and Wood (2000) show that trading in decimals has reduced quoted and effective spreads for the first few sets of pilot stocks.[40] Additionally, they find a decline in depth. Bacidore, Battalio, and Jennings (2001) find reduced

[38] See Bacidore (1997), Porter and Weaver (1997), and MacKinnon and Nimeroff (1999).
[39] See Griffiths, *et al.* (1998).
[40] See Chapter 1 for details on the transition to decimal trading.

liquidity in both the limit order book and displayed quotes. Furthermore, the supply of limit orders and the specialists' quote size both declined. They show that member firms provide more liquidity, but individuals provide less liquidity, after the move to decimals on the NYSE.

Nasdaq Economic Research (2001) investigates the impact of Decimalization on the Nasdaq Stock Market in its final report to the Securities and Exchange Commission. Using data for all stocks that converted to decimal quoting on April 9, 2001, the paper investigates changes in Nasdaq characteristics occurring between the two weeks preceding and the two weeks following the conversion to quoting in decimals.

Nasdaq Economic Research notes an important caveat concerning the Final Report to the SEC. The report states that "...it attempts to measure the *initial* impacts of decimals only. In light of the major changes it has induced, it is possible if not likely the ultimate impact of the decimals may take a number of months to reveal itself. Many markets participants, investors as well as market intermediaries, are in the process adapting to the new trading environment. It is also possible that some of the observed results are due to a novelty effect. What we measure in the first two weeks maybe substantially different a year from now." Thus, although the Nasdaq Economic Research Final Report to the SEC is informative, it does not provide any long-term evidence of the impacts of moving trading to decimals. Consequently, this long-term investigation will help policy makers determine if the anticipated outcome of decimalization is reached. Nonetheless, it is worthwhile to review the preliminary findings presented in the Final Report to the SEC.

The Nasdaq Final Report to the SEC finds that after controlling for the day-to-day fluctuations in trading activity, the number of quote updates increased by 12 percent or more. However, there was little change in the number of trades or share volume. Quoted and effective spreads declined for most stocks, by an average of 50 percent. Although large institutional orders' transaction costs do not appear to have risen, small retail orders benefited the most from reduced spreads. The quoted size posted at the inside fell about two-thirds, but the cumulative displayed depth fell by a much smaller percentage. No increase in intra-day volatility was found.

Informational-sensitive liquidity traders attempt to distinguish informed traders from uninformed traders. Several studies find evidence of liquidity traders' attempts to distinguish informed and uninformed traders using both the bid-ask spread and the price impact of a trade. Easley and O'Hara (1987) and Hasbrouck (1988) uncover a positive relationship between price impact and trade size. This suggests that informed agents trade more heavily in an attempt to profit from their depreciating informational advantages. McInish and Wood (1992) show that the bid-ask spread widens following large volume orders.

Foster and Viswanathan (1995) suggest that the intensity of trading may be positively correlated with the proportion of informed agents because informed agents are often constrained by the time sensitivity of their information. Consequently, since the number of transactions or the number of shares per unit of time measure the intensity of trading activity, they should be a function of information asymmetry.

Engle and Lange (2001) use NYSE transaction and quote data from November 1, 1990 to January 31, 1991, and from August 1997 through December 1997, to identify, measure and model intraday variations in the market depth of individual stocks. They propose a new intraday measure of market liquidity, VNET, which directly measures the depth of the market corresponding to a particular price deterioration. They find that market depth varies with volume, transactions, and volatility. They interpret changes in the market depth in terms of the varying proportion of informed traders in an asymmetric information model.

Engle and Lange estimate their model for the length of a price-duration (PTIME) and the net directional volume traded within a price duration (VNET) over the two time periods and find similar parameter estimates. They conclude that the stability of the price estimates suggests that their price-duration approach captures some of the fundamental determinants of equity market liquidity.

Using VNET, Engle and Lange estimate the shape of the market reaction curve. They find that the realized depth of the market varies according to trading conditions. Furthermore, the percentage imbalance between buys and sells sufficient to move prices declines with the total number of shares traded. The number of transactions per duration reduces the depth of the market. This supports the idea that informed traders flood the market after a semi-private news event. Additionally, movements in VNET are negatively correlated with movements in the bid-ask spread. The positive impact of the expected duration length on expected VNET suggests that when the market is volatile, it will offer less depth. Unanticipated shocks to the length of a price duration increase realized depth. The authors conclude that these results carry the implication that trading behavior may play a significant role in shaping and predicting the intraday liquidity of the stock market.

Easley, Engle, O'Hara, and Wu (2001) propose a dynamic model of trading and estimate the model on 16 actively traded stocks on the New York Stock Exchange over 15 years of transactions data. They investigate the implications of trade dynamics on security price processes such as market liquidity, depth, and volatility.

Easley, Engle, O'Hara, and Wu estimate the price impact of a sequence of trade orders, i.e. buy orders and sell orders, based on Bayes updating. Given arrival rate forecasts, they construct a measure of market depth, the half life of the price impacts for consecutive buys, analogous to Engle and Lange's market depth measure VNET.

VNET and the half life measure of Easley et al. differ in at least two ways. First, VNET is defined by the excess trading volume while the half life is only concerned with the number of trades. Additionally, trade size is not considered in the half life. Second, VNET implicitly assumes that only the net trade imbalance matters on the price movement. That is, the sequence of trades is of no consequence. However, the half life assumes that the exact sequence of trading plays a role in the price movement. Consequently, the half life is based on the consecutive number of buys instead of net order flows.

Easley *et al*. find that the half lives for most stocks are positively correlated with the total number of trades. Consequently, the market is deeper in the presence of more trades. Additionally, they show that the half lives for most stocks are negatively correlated with the ratio of trade imbalance over total trades, suggesting that market depth decreases with the proportion of informed trades. Finally, the authors show that differences in mean half life exist across stocks, demonstrating differences in market depth.

Data

The data for this study were retrieved from the Nastraq and TAQ databases. Nastraq and TAQ are publicly available trade and quote data offered by Nasdaq and the New York Stock Exchange, respectively. All trades, quotes, trade times, quote times, trade sizes, quote sizes, and market maker identifiers for each quote are obtained from Nastraq for a sample of 100 Nasdaq listed companies. All trades, quotes, trade times, quote times, trade sizes, and quote sizes are obtained from TAQ for a sample of 100 NYSE listed companies.

To investigate differences in market depth between the NYSE and Nasdaq, two matched portfolios are created. Firms are matched on the number of shares traded. First, all NYSE listed firms are ranked by the number of shares traded during December 1998 and placed into share volume deciles. The ten firms with the highest volume from each decile are chosen, for a total of 100 firms. Next, all Nasdaq listed companies are sorted by number of shares traded during December 1998. Documented differences in trade reporting procedures between the NYSE and Nasdaq require Nasdaq trade volume to be adjusted to be comparable to NYSE trade volume.[41] Therefore, the number of shares traded for Nasdaq companies is divided by 2. Lastly, the closest Nasdaq adjusted volume is identified for each NYSE company. Any duplicate matches are eliminated by keeping the closest match and re-matching the duplicate (i.e. The Nasdaq companies are sampled without replacement.)

The high computational costs of trade and quote data cause researchers to limit both the number of companies and length of the period under investigation when

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[41] See Daves, Wansley, and Zhang (2003) and Dyl and Anderson (2003).

investigating microstructure issues. For example, Engle and Lange (2001) use a sample of 17 NYSE listed, actively traded companies over 61 trading days to investigate market liquidity. Similarly, the sample employed here is limited to keep computational costs manageable.

For both the NYSE and Nasdaq portfolios, data are obtained covering four two-week periods; a two-week trading period one-year prior to the move to trading in decimals, the two-week period immediately preceding the move to trading in decimals, the two-week period immediately following decimalization, and a two-week period occurring one year after the beginning of trading in decimals.

The portfolio of Nasdaq companies is created from those companies that were subject to trading in decimals on April 19, 2001. Consequently, the period before decimalization ranges from Thursday, April 5, 2001 through Wednesday, April 18, 2001. The related one-year prior period is from April 19, 1999 to April 30, 1999. The immediate post period is from April 19, 2001 to May 2, 2001. The one-year anniversary post period extends from Friday, April 19, 2002 to Thursday, May 2, 2002.

The second portfolio includes only NYSE listed companies that were subject to trading in decimals on January 29, 2001. The companies in this portfolio are also selected by the ranking procedure detailed for Nasdaq listed companies. Therefore, the NYSE portfolio also includes 100 companies.

The portfolio of NYSE companies is a subset of those companies that were subject to trading in decimals on January 15, 2001. Consequently, the one-year prior period is from January 29, 1999 to February 11, 1999. The sample period before decimalization ranges from Monday, January 15, 2001 through Friday, January 26, 2001.

The immediate post period is from January 29, 2001 to February 9, 2001. The one-year anniversary post period extends from Tuesday, January 29, 2002 to Monday, February 11, 2002. The resulting portfolios of stocks for the NYSE and Nasdaq are presented in Table 1.

2B. Methodology

Several steps are required to measure or forecast the impact of Alternative Trading Systems on market depth. First, the VNET measure of Engle and Lange (2001) is computed. Next, the conditional expectation of the time between price changes is estimated. Lastly, a cross-sectional time series model of market depth is estimated.

Engle and Lange (2001) propose a new intraday measure of market liquidity-VNET. VNET defines market depth as the number of shares that can be bought or sold within a given price range. Given this definition of market depth, Engle and Lange argue that the measurement interval for a technique used to estimate market depth should be dictated by price levels, instead of calendar time. Consequently, VNET is created to directly measure the depth of the market corresponding to a particular price interval or duration.

VNET defines the realized depth of the market as the imbalance between the number of shares bought and the number of shares sold within a pre-specified price duration. To compute VNET, a price threshold must first be specified for each individual company. For example, Engle and Lange specify the price threshold for Exxon to be $1/8.

Table 1: Study Sample

A matched sample approach is used to select the companies included in the study. First, all NYSE firms are ranked by the number of shares traded in December 1998 and placed into share volume deciles. The ten firms with the highest volume are chosen from each decile for a total of 100 firms. The matched sample of Nasdaq listed firms is created by choosing for each NYSE firm, the Nasdaq listed company that traded the most similar share volume during December 1998.*

Nasdaq				NYSE			
Nasdaq Firm	Shares Traded	Nasdaq Firm	Shares Traded	NYSE Firm	Shares Traded	NYSE Firm	Shares Traded
SMXC	305300	MEDX	4347300	MUO	153100	E	2169300
DUCK	312500	OSIP	4349000	VIM	153600	GVA	2175800
TACX	315300	WORK	4350400	PAI	156000	AC	2176100
ASCA	316000	ALKS	4360200	SKP	157600	MHK	2180600
PENX	316700	EXBT	4392900	MHO	158200	COE	2197400
LUFK	321200	VNWK	4400100	VCV	158600	HMX	2201800
HUBG	322800	ANAD	4406800	AK	160700	LDG	2202900
THRD	324200	EMMS	4428100	CBA	161400	BQT	2209300
DIAN	326100	REMC	4433400	AMN	162100	WNC	2214800
SCSC	648700	TOPP	4434000	SCL	162800	WRC	2215400
ATGI	651900	DRTE	7252200	IQM	325500	PIM	3687000
HRLY	653100	PRST	7276600	STW	325500	TSO	3724400
RCCC	653700	ASFC	7341300	AMU	325800	BNO	3726200
NEOG	659300	CAND	7365500	IMT	326400	MIL	3733500
PCDI	660200	RGBK	7385100	GAM	329600	DY	3735100
AVTR	660200	APAC	7406900	NGI	330100	EL	3742900
MDEA	662500	HMSY	7424800	NUC	331200	JP	3749300
PLFE	665500	SCFS	7429400	ALZ	333200	COO	3754500
BVAS	668300	DSTM	7481400	CNE	333900	FTS	3773700
AULT	672400	DAVX	7528900	PPM	336200	PSA	3787200
DRYR	1083200	NTAP	12293900	BKH	541200	AGE	6177400
RICK	1084500	SPLN	12312800	EGP	542300	UCU	6210400
MINI	1089900	SOTR	12407600	PEI	545600	WPI	6217400
BTRN	1091500	MEDI	12422200	SBR	546300	PNM	6219200
TECUA	1110600	PTEN	12556600	SEL	555100	USU	6269000

Table 1 Continued

A matched sample approach is used to select the companies included in the study. First, all NYSE firms are ranked by the number of shares traded in December 1998 and placed into share volume deciles. The ten firms with the highest volume are chosen from each decile for a total of 100 firms. The matched sample of Nasdaq listed firms is created by choosing for each NYSE firm, the Nasdaq listed company that traded the most similar share volume during December 1998.*

Nasdaq				NYSE			
Nasdaq Firm	Shares Traded	Nasdaq Firm	Shares Traded	NYSE Firm	Shares Traded	NYSE Firm	Shares Traded
TACT	1113800	NETM	12588400	WES	559200	PPL	6299000
HOFF	1117300	TRAC	12712100	DEL	559900	ETN	6350500
LTRE	1122900	TWMC	12728100	FCF	560400	DOL	6351100
BITS	1123600	HLYW	12751600	BMT	560800	AHG	6375100
ODETA	1124400	PCCC	12827600	APX	561100	TEO	6406100
HGSI	1777700	CELL	23740000	FRT	891500	TDP	13387800
NATR	1780100	ADSK	23963900	MDA	894300	PCG	13420300
OPTI	1794500	INSP	24965100	VLY	898100	GLW	13434300
ZIGO	1797800	BBBY	25509400	ETT	903300	APA	13655800
CBUK	1809100	SANM	25590200	BLX	904600	NR	13814900
LARS	1809600	CHIR	26111400	TLD	904800	PZL	13838100
QADI	1826900	AMKR	27277900	PKE	905700	ZAP	13979000
SNAP	1834800	CENT	27566800	LFG	905800	BAX	14018200
LNCB	1835900	PETM	28693500	ION	911500	KSS	14172900
FUTR	1839300	VTSS	30414700	RYL	911900	TSM	14210900
QDIN	2821900	BAMM	115917300	GFF	1424500	BAC	97396500
ITIG	2823500	PSFT	118707900	ESF	1426000	MU	104150000
FSII	2824800	AMAT	139334500	FOE	1427700	DIS	111583800
ALXN	2838400	YHOO	143294200	RI	1428200	SLB	113698300
DTPI	2844000	COMS	171464600	WLT	1433000	MO	114796000
APLX	2852100	ORCL	193926000	POS	1433100	T	128630300
GLFD	2856800	WCOM	283639400	ATS	1434800	LU	133647700
ANSR	2885600	MSFT	308842100	GRB	1441100	CD	138146700
BSTE	2893800	INTC	311089200	IPP	1445600	C	145404500
BKUNA	2911500	CSCO	349695900	MM	1447400	BA	163745500

* Reported share volume count differences between the NYSE and Nasdaq are adjusted for by dividing Nasdaq reported share volume by 2.

When a price quote moves beyond the specified threshold, a price or information event is said to have occurred, signaling the end of a price duration.[42] Alternatively, a return threshold can be used to identify an informational event. I choose to use return thresholds because share price differences across stocks cause a given price change to have different importance across those stocks. For example, a price move of $0.25 for a $1000 stock is small, but the same price move for a $1 stock is large.

Identifying the level of return threshold that is consistent with being an informational event is somewhat arbitrary and has not been addressed by researchers. Consequently, I investigate the effects of different return thresholds on the number of informational events identified by each threshold. The pre-specified return thresholds are 0.15%, 0.50%, 1.00%, 2.00%, and 5.00%.

Once the price or return threshold is specified, all signed trades that occurred since the last information event, not including the current informational event, are summed. Therefore, VNET determines the net directional volume that was traded before a price quote moves beyond a specified price threshold. Formally,

$$VNET_j = \log \left| \sum_i d_{ij} vol_{ij} \right|, \tag{1}$$

where d is the direction of the trade indicator (sell = -1 and buy = 1) and vol is the number of shares traded on the i^{th} transaction during the j^{th} duration for a given company. The summation is over all transactions within a given price-duration. VNET is computed in log levels.

[42] Engle and Lange (2001) include the additional constraint that at least two consecutive data points must exceed the chosen price threshold to signal the end of a price duration.

Since the TAQ and NASTRAQ databases do not specify whether a trade was buyer-initiated or seller-initiated, a modified version of the Lee and Ready (1991) algorithm is used to determine whether a trade was buyer-initiated or seller-initiated. The modified Lee and Ready algorithm involves three steps. First, trades are associated with specific quotes by matching transactions to quotes that are at least five seconds old. This is necessary because new quotes can be posted more quickly than transactions can be recorded. Next, the bid-ask midpoint is computed for each quotation. Lastly, a transaction with a price that is greater than the prevailing midpoint is identified as a buy, while a transaction price that is lower than and the prevailing midpoint is considered a sell. If the trade price equals the prevailing midpoint then the tick rule is applied; when the transaction price at time t is greater than the transaction price at time $(t - 1)$ then the trade is considered a buy, otherwise it is a sell.

A graphical example of the calculation of VNET is presented in Figure 2. The opening stock price is $20 and the chosen price threshold is $0.25. The first event occurs when the stock price increases from $20 to $20 5/8, following the 200 share buy, surpassing the $0.25 threshold. Consequently, the first price duration, $VNET_1$, equals log (600) shares (100+300+200). The second event is marked following the 500 share sell, pushing the stock price down to $20 from $20 5/8. The corresponding measure of market depth, $VNET_2$ equals log (200) shares (300+100+300-500). As a result, $VNET_3$, is log (100) shares (300+100-300-200). $VNET_4$ equals log (200). No price change is associated with the final transaction.

Prior time series research methods fail to consider that price quotes and trades arrive in irregular time intervals.

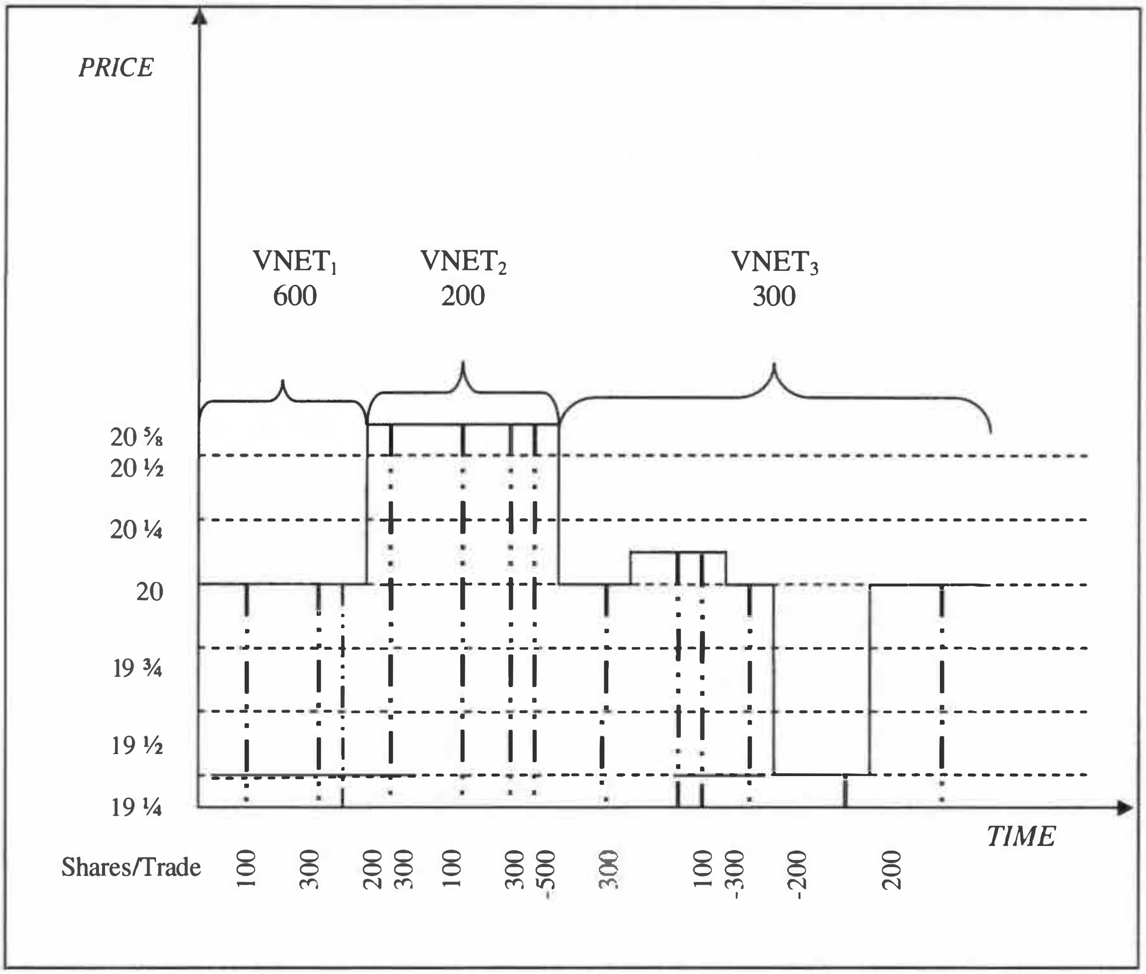

Figure 2. VNET Example with the Price Threshold = 0.25 (Not in Log Levels)

If the variability in the amount of one-sided volume that can be sustained before prices adjust contains information about the degree of information asymmetry in the market, then the time between price events should be considered when attempting to explain variation in market depth. For instance, Engle and Lange show that the amount of one-sided volume (VNET) that can be sustained before prices adjust is not constant over time for a given stock. Perhaps the failure of prior models to consider the irregular arrival rates of trades and quotes contributes to the lack of clarity about the role that liquidity proxies, such as the bid-ask spread and bid-ask quote sizes, play in explaining time variation in trade impacts. For example, Hasbrouck and Seppi (2001) choose a common time interval of 15 minutes to specify the data they use in a principal components analysis of common factors in order flows and returns. They find that although both returns and order flows are characterized by common factors, common factors in bid-ask spreads and bid-ask quote sizes are relatively small.

Engle and Russell (1998) introduce the autoregressive conditional duration (ACD) model that allows data to arrive in unequal time intervals. Instead of requiring researchers to aggregate information within a given time interval, the ACD model allows researchers to treat the arrival times of the data as a point process with an intensity defined conditional on past activity. Thus, the ACD model can be used to predict how long it will be until prices change. While it is not the goal of this research to forecast the time between price changes, it is important to include the conditional expectation of the time between price changes to forecast market depth.

The conditional expectation of the time between price changes is obtained from the ACD model of Engle and Russell (1998).[43] Let PTIME be the elapsed clock time between two events identified in computing VNET. Additionally, let EPTIME be the conditional expectation of PTIME.

A two-step procedure is used to estimate the expected duration, EPTIME. First, PTIME is fitted on 8 knot-points using a spline. The knot-points are chosen to reflect the U-shaped pattern of trading activity reflected in the literature; 9:30, 10:00, 11:00, 12:00, 1:00, 2:00, 3:00, 3:30.[44] Next, each observation of PTIME is divided by the estimated coefficient for the time-of-day interval during which the price change occurred. The result is the expected time between price changes or duration, EPTIME.[45]

Finally, a model to estimate ATS' impacts on market depth over a price-duration is developed. This model borrows from the specification of Engle and Lange (2001).

The first model tests for differences in VNET between the NYSE and Nasdaq in a multivariate framework. The specification employs the explanatory variables from Engle and Lange as control variables. The model is presented in equation 1A.

The first model is extended to include binary variables to test for differences in market depth by volume deciles. Equation 1B presents this formulation.

To measure the impact of Alternative Trading Systems on market depth, three new variables are introduced to the model. The variable %ECNQ is the proportion of all quotes posted to Nasdaq that are submitted through an ECN. The variable %SNET is the

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[43] Engle and Lange (2001) employ the following ACD model to forecast the time between price changes; $EPTIME_t = \omega + \alpha_1 PTIME_{t-1} + \beta_1 EPTIME_{t-1} + \varphi_1 SPR\_NOM_{t-1}$, where, EPTIME is the conditional expectation of the elapsed clock time, PTIME is the elapsed clock time, and SPR_NOM is the nominal bid-ask spread.

[44] For example, see Barclay et al. (1999).

[45] EPTIME is the same as Engle and Russell's (1997) 'seasonally adjusted' set of durations.

proportion of all trades executed through SelectNet and %SOES is the proportion of all trades executed through SOES.[46] The model specification is presented in equation 2A.

Lastly, the ATS specification is extended to include binary variables to test for differences in market depth by volume deciles and is offered in equation 2B.

The explanatory variables in the models are:

TWASpread	= the time-weighted average bid-ask spread during the price-duration,
Vol	= the log of the total volume traded during the price-duration,
Trades	= the number of trades during the price-duration,
Ptime	= the elapsed clock time between price-durations,
Eptime	= the conditional expectation of Ptime,
Ptime_err	= the log of (Ptime / Eptime),
ECN	= the proportion of all quotes posted by ECNs over the duration,
SelectNet	= the proportion of all trades executed through SelectNet over the duration,
SOES	= the proportion of all trades executed through SOES over the duration,
NYSE	= binary variable equal to 1 if company is NYSE listed, otherwise equal to 0,
Pre2001	= binary variable equal to 1 if observation occurred during the pre-decimalization 2001 period, 0 otherwise,
Post2001	= binary variable equal to 1 if observation occurred during the post-decimalization 2001 period, 0 otherwise,
Post2002	= binary variable equal to 1 if observation occurred during the 2002 period, 0 otherwise,
Pre2001NYSE	= NYSE times Pre2001,
Post2001NYSE	= NYSE times Post2001,
Post2002NYSE	= NYSE times Post2001,
Decile1	= binary variable equal to 1 if company's share volume is in decile 1, otherwise equal to 0,
Decile2	= binary variable equal to 1 if company's share volume is in decile 2, otherwise equal to 0,
Decile3	= binary variable equal to 1 if company's share volume is in decile 3, otherwise equal to 0,
Decile4	= binary variable equal to 1 if company's share volume is in decile 4, otherwise equal to 0,
Decile5	= binary variable equal to 1 if company's share volume is in decile 5, otherwise equal to 0,

[46] The sum of the variables ECN, SelectNet, and SOES is not required to equal 1. Although the Nastraq database includes identifiers for trades executed through SOES and SelectNet, it does not include a identifier for trades executed through ECNs. Consequently, the degree of trading through ECNs is proxied by the proportion of all quotes posted to Nasdaq that are submitted through ECNs.

Decile6 = binary variable equal to 1 if company's share volume is in decile 6, otherwise equal to 0,
Decile7 = binary variable equal to 1 if company's share volume is in decile 7, otherwise equal to 0,
Decile8 = binary variable equal to 1 if company's share volume is in decile 8, otherwise equal to 0,
Decile9 = binary variable equal to 1 if company's share volume is in decile 9, otherwise equal to 0.

Formally,

$$VNET_{it} = \alpha + \beta_1 TWASpread_{it-1} + \beta_2 Vol_{it-1} + \beta_3 Trades_{it-1} + \beta_4 Eptime_{it} + \beta_5 Ptime\_err_{it} + \beta_6 NYSE_i + \varepsilon_{it} \quad (1A)$$

$$VNET_{it} = \alpha + \beta_1 TWASpread_{it-1} + \beta_2 Trades_{it-1} + \beta_3 Eptime_{it} + \beta_4 Ptime\_err_{it} + \beta_5 NYSE_i + \beta_5 NYSE_i + \beta_6 Pre2001_i + \beta_7 Post2001_i + \beta_8 Post2002_i + \beta_9 Pre2001NYSE_i + \beta_{10} Post2001NYSE_i + \beta_{11} Post2002NYSE_i + \beta_{12} Decile1_i + \beta_{13} Decile2_i + \beta_{14} Decile3_i + \beta_{15} Decile4_i + \beta_{16} Decile5_i + \beta_{17} Decile6_i + \beta_{18} Decile7_i + \beta_{19} Decile8_i + \beta_{20} Decile9_i + \varepsilon_{it} \quad (1B)$$

$$VNET_{it} = \alpha + \beta_1 TWASpread_{it-1} + \beta_2 Vol_{it-1} + \beta_3 Trades_{it-1} + \beta_4 Eptime_{it} + \beta_5 Ptime\_err_{it} + \beta_6 ECN_{it} + \beta_7 SelectNet_{it} + \beta_8 SOES_{it} + \varepsilon_{it} \quad (2A)$$

$$VNET_{it} = \alpha + \beta_1 TWASpread_{it-1} + \beta_2 Trades_{it-1} + \beta_3 Eptime_{it} + B_4 Ptime\_err_{it} + \beta_5 ECN_{it} + \beta_6 SelectNet_{it} + \beta_7 SOES_{it} +$$

$$B_8 Decile1_i + \beta_9 Decile2_i + \beta_{10} Decile3_i + \beta_{11} Decile4_i +$$

$$\beta_{12} Decile5_i + \beta_{13} Decile6_i + \beta_{14} Decile7_i + \beta_{15} Decile8_i +$$

$$\beta_{16} Decile9_i + \varepsilon_{it} \qquad (2B)$$

Engle and Lange estimate a number of different specifications of the model to forecast market depth over a price-duration. Using a pooled regression, the following relationships are established.

Spreads of the final trade for the previous price-duration are negatively related to VNET. Therefore, as spreads widen, depth decreases.

Engle and Lange find the log of the total volume traded during the previous price-duration (Vol_{j-1}) is positively related to VNET. Therefore, higher trading volume and share prices result in a smaller percentage imbalance in orders. The log of the number of trades during the previous price-duration ($Trades_{j-1}$) is negatively related to VNET, supporting the idea that periods of high trading reflect an influx of informed traders.

Additionally, the log of the conditional expectation of the time between price changes, the log of Eptime, and the log of the error of the forecast of the time between price changes, Ptime_err are estimated to be positively related to VNET. The positive relationship between the expected time for prices to move and market depth reflects the expectation that lower volatility is associated with less informed trading. Consequently, higher expected times between price changes reflect lower information asymmetry. The positive relationship between the error in forecasting the time length of a price-duration and market depth demonstrates traders' attempts to execute transactions before the next expected price change.

Assuming that the benefits of the posting of limit orders to ECNs are dominated by the negative effects of greater trader anonymity, then as the proportion of the total number of trades executed through an ECN increases for a given company, market depth should decrease.

SelectNet allows market participants to reveal their identity when electronically negotiating the terms of a trade. When an investor chooses to reveal his identity, it is less likely that he is attempting to exploit the counterparty by taking advantage of private information. Consequently, counterparties should be more willing to negotiate favorable trade terms through SelectNet. As a result, SelectNet should increase market depth.

The effects of Nasdaq's Small Order Execution System are less clear. Orders executed through SOES tend to be small, individual investor orders. However, the orders are anonymous. Assuming that the small share sizes of SOES trades minimizes anonymous traders' ability to take advantage of perishable private information, higher proportions of trades executed through the SOES should increase market depth.

Hypotheses for the Effects of Decimalization on Depth

Preliminary research finds that smaller bid-ask spreads result following the introduction of trading in decimals.[47] Consequently, price-quote size curves created for the bid side of the market and the ask side of the market must move closer together. There are at least four possible movements along or by bid-curves and ask-curves that result in smaller spreads. The theoretical equilibrium market price in a world with no frictions is represented by the intersection of the bid curve with the ask curve.

[47] See Chakravarty and Wood (2000) and Nasdaq Economic Research (2001).

Market participants can change their quotation behavior in four ways that are consistent with the expectation of smaller bid-ask spreads. First, market participants can quote such that the bid and ask curves stay the same. However, traders move down the ask curve and up the bid curve, thereby narrowing the bid-ask spread. Second, both the bid curve and ask curve may pivot simultaneously, causing quoted spreads to narrow. In this case, both quoted volume on the bid side of the market and the ask side of the market will increase. However, equilibrium market prices will remain the same.

When the bid curve shifts downward and pivots and there is no movement by the ask curve, then quoted volume will decrease on the bid side of the market and equilibrium market prices will decrease. Similarly, when the ask curve shifts upward and pivots, quoted volume on the ask side of the market decreases with an increase in the equilibrium price.

In summary, the move to trade in decimals can affect bid curves and ask curves, causing changes in equilibrium prices and quoted volumes. Movement along the bid curve and ask curve will cause a drop in quoted volume. Similarly, when either the bid curve or ask curve pivots and shifts, quoted volume will decrease. However, a simultaneous pivot in the bid curve and ask curve will cause higher quoted volume with no associated change in equilibrium prices. Formally, Hypotheses I and Hypotheses II follow.

Hypothesis 1:

Market participants change their quotation behavior causing a simultaneous pivot in the bid curve and the ask curve. The movement in the curves causes quoted volume to increase. Consequently, VNET increases.

Hypothesis 2:

Market participants change their quotation behavior causing a drop in quoted volume. The drop results from a pivot and shift in the bid curve or the ask curve, or a simultaneous shift down the ask curve and up the bid curve. Consequently, VNET decreases.

Hypotheses for the Effects of Alternative Trading Systems on Depth

Hypothesis 3:

The benefits of posting customer limit orders through ECNs outweighs the costs of trader anonymity. In the Admati and Pfleiderer (1988) framework where liquidity traders and informed traders prefer to trade during active periods, informed traders are less likely to be recognized because of the high number of active traders. Consequently, companies with more ECN trade and quote activity should have increased depth.

Hypothesis 4:

The higher adverse selection costs arising from trader anonymity dominate all possible benefits arising from ECN participation. Consequently, companies with more ECN trade and quote activity should have decreased depth.

Hypothesis 5:

SelectNet users can reveal their identities, thereby reducing adverse selection costs. As a result, higher proportions of non-anonymous SelectNet trades should result in increased trading and depth.

Hypothesis 6:

SelectNet users can directly negotiate individual trade parameters. Direct negotiations require more time and effort to complete. Therefore, fewer trades will be executed. If average trade size does not increase enough to offset the decrease in the number of trades, then total trading volume should drop. Consequently, depth should decrease.

Hypothesis 7:

SOES trades are small anonymous trades. Mandated small order sizes minimize traders' ability to use perishable information. Therefore, higher proportions of SOES trading should result in increased trading and depth.

Chapter 3 Changes in Depth Results

3A. Unconditional Results

Table 2 presents VNET summary statistics by trading volume ranked deciles for the NYSE during the 1999, pre-decimalization 2001, post-decimalization 2001, and 2002 periods. The averages show that VNET tends to almost always increase as the pre-specified threshold increases for each of the four two-week trading periods. For instance, average VNET increases from 6.98 for the 0.15% threshold to 10.39 for the 5.00% threshold for the low volume (0) decile in 1999. Similarly, VNET generally increases as trading volume increases, regardless of the time period. For example, VNET increases from 8.02 for the low volume (0) decile to 9.91 for the high volume (9) decile for the 0.50% threshold in 1999. Therefore, higher net numbers of shares are required to induce pre-specified returns in the presence of increased volume. Also, higher net numbers of shares are required to induce larger returns.

VNET summary statistics by trading volume ranked deciles for the Nasdaq sample of firms are provided in Table 3. Consistently, the frequency of informational events decreases as the return threshold increases. For example, consider the high volume (9) decile during the 2001 pre-decimalization period. The number of events drops from 11,950 for the 0.15% threshold to 27 for the 5.00% threshold. Therefore, this suggests 2.7 informational events per company over the 10 day period, or 0.27 informational events per company per day at the 5.00% return threshold.

In general, Tables 2 and 3 suggest that VNET or depth is higher on the NYSE compared to Nasdaq during 1999 and 2001. However, it appears that VNET is higher on the Nasdaq during the 2002 period. This will be further investigated later.

Table 2: VNET Summary Statistics by Trading Volume Ranked Deciles for NYSE

Summary statistics are computed for VNET across four two-week trading periods using five different threshold returns (0.15%,0.5%,1%,2%,5%). Firms are placed into deciles by ranking according to total monthly trading volume in December 1998 for NYSE listed companies.

$VNET_{j,k} = \log\left|\sum_i \left(d_{i,j}^k \times vol_{i,j}^k\right)\right|$ where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each j th duration for company k.

1999		Low Volume				Decile					High Volume
Threshold		0	1	2	3	4	5	6	7	8	9
0.15%	Mean	6.98	7.27	7.14	7.16	7.13	7.43	7.42	7.63	7.43	8.35
0.50%	Mean	8.02	7.98	8.31	8.21	8.40	8.16	8.26	8.87	8.36	9.91
1.00%	Mean	8.41	7.91	8.71	8.72	8.98	8.80	8.55	9.72	9.02	10.74
2.00%	Mean	8.95	7.98	8.65	8.89	9.56	9.21	9.10	10.02	9.56	11.41
5.00%	Mean	10.39	7.95	9.21	9.04	9.63	9.90	9.54	10.43	10.70	12.25
0.15%	Frequency	1528	1336	2870	4956	7265	7847	9184	15335	25732	57049
0.50%	Frequency	338	334	757	1421	2011	2591	2746	3739	8957	8975
1.00%	Frequency	134	150	284	552	682	1010	1311	1244	3937	2769
2.00%	Frequency	57	84	112	140	249	320	449	427	1758	691
5.00%	Frequency	9	4	20	17	35	33	63	58	260	113
0.15%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
0.50%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
1.00%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
2.00%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
5.00%	Minimum	8.29	6.91	5.30	4.61	5.30	5.70	4.61	5.99	5.70	4.61
0.15%	Maximum	11.95	10.71	11.67	15.15	12.45	14.47	13.52	15.30	15.83	15.07
0.50%	Maximum	12.30	11.00	11.86	15.15	13.71	14.64	13.51	15.29	15.83	15.48
1.00%	Maximum	11.92	11.08	12.13	15.15	13.21	14.44	13.45	14.13	15.83	15.50
2.00%	Maximum	11.76	10.84	11.58	13.11	13.11	13.10	13.31	13.92	15.84	15.51
5.00%	Maximum	11.64	9.65	11.31	12.74	11.76	13.21	13.09	13.35	16.23	15.42
0.15%	Standard Deviation	1.27	1.29	1.37	1.40	1.53	1.58	1.52	1.61	1.70	1.80
0.50%	Standard Deviation	1.38	1.48	1.51	1.52	1.66	1.78	1.67	1.69	1.89	1.79
1.00%	Standard Deviation	1.45	1.53	1.59	1.64	1.77	1.80	1.91	1.78	1.92	1.79
2.00%	Standard Deviation	1.34	1.31	1.69	1.90	1.84	1.76	1.98	1.87	1.98	1.81
5.00%	Standard Deviation	1.14	1.18	1.53	2.43	1.67	1.93	2.01	2.21	1.55	1.94

Table 2 Continued

Summary statistics are computed for VNET across four two-week trading periods using five different threshold returns (0.15%,0.5%,1%,2%,5%). Firms are placed into deciles by ranking according to total monthly trading volume in December 1998 for NYSE listed companies.

$$VNET_{j,k} = \log\left|\sum_i \left(d_{i,j}^k \times vol_{i,j}^k\right)\right|$$ where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each jth duration for company k.

2001 Pre-Decimalization		Low Volume				Decile					High Volume
Threshold		0	1	2	3	4	5	6	7	8	9
0.15%	Mean	6.53	6.92	6.57	6.69	6.97	6.72	6.99	7.01	7.05	7.45
0.50%	Mean	7.02	7.32	7.13	7.39	7.37	7.23	7.91	7.66	7.82	8.60
1.00%	Mean	7.69	7.61	7.71	8.32	7.75	7.75	8.53	8.61	8.21	9.53
2.00%	Mean	8.67	7.99	8.44	8.56	8.31	8.09	9.13	9.48	9.00	10.43
5.00%	Mean	9.63	8.42	9.11	8.44	9.02	8.26	9.40	10.47	10.22	11.54
0.15%	Frequency	4218	2434	6245	14620	13164	13027	29308	40404	95336	158040
0.50%	Frequency	2753	1452	3664	6522	8795	6681	10419	18812	41292	53724
1.00%	Frequency	1247	857	1694	1934	4769	2996	3986	6530	25921	20381
2.00%	Frequency	264	306	541	565	1762	1280	1497	2038	10609	6935
5.00%	Frequency	31	45	117	129	328	394	428	432	2099	1549
0.15%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
0.50%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
1.00%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
2.00%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
5.00%	Minimum	5.99	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
0.15%	Maximum	11.24	11.71	11.74	14.55	14.75	13.30	14.13	14.39	15.09	15.10
0.50%	Maximum	11.93	11.69	11.88	14.56	15.15	13.60	14.14	14.96	15.09	15.16
1.00%	Maximum	11.31	11.99	12.33	14.56	15.15	13.68	14.13	14.95	15.09	15.19
2.00%	Maximum	11.81	11.99	12.30	13.75	15.15	13.82	14.28	14.96	15.09	15.22
5.00%	Maximum	11.68	12.64	12.11	12.93	15.11	13.91	14.17	14.89	15.39	15.20
0.15%	Standard Deviation	1.35	1.30	1.29	1.41	1.52	1.41	1.54	1.48	1.62	1.79
0.50%	Standard Deviation	1.45	1.42	1.41	1.56	1.64	1.54	1.72	1.64	1.77	1.93
1.00%	Standard Deviation	1.47	1.49	1.53	1.67	1.78	1.67	1.83	1.77	1.83	1.93
2.00%	Standard Deviation	1.57	1.67	1.61	2.02	1.99	1.68	1.92	1.89	1.84	1.97
5.00%	Standard Deviation	1.34	1.77	1.93	2.17	2.11	1.87	2.29	1.78	1.94	1.96

Table 2 Continued

Summary statistics are computed for VNET across four two-week trading periods using five different threshold returns (0.15%,0.5%,1%,2%,5%). Firms are placed into deciles by ranking according to total monthly trading volume in December 1998 for NYSE listed companies.

$VNET_{j,k} = \log\left|\sum_i \left(d_{i,j}^k \times vol_{i,j}^k\right)\right|$ where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each j th duration for company k .

2001	Post-Decimalization	Low Volume				Decile					High Volume
Threshold		0	1	2	3	4	5	6	7	8	9
0.15%	Mean	7.70	7.42	6.92	7.38	7.32	7.12	7.67	7.35	7.53	8.00
0.50%	Mean	8.51	7.73	7.39	7.73	7.90	7.70	7.98	8.00	8.17	8.96
1.00%	Mean	9.05	7.88	7.50	7.92	8.12	7.97	7.93	8.46	8.28	9.32
2.00%	Mean	9.11	7.84	7.51	7.86	8.75	8.30	8.42	8.70	8.23	9.47
5.00%	Mean	9.58	8.72	8.37	8.14	9.21	8.79	8.62	9.44	8.91	10.16
0.15%	Frequency	2270	1179	4204	6313	7023	8236	10842	21683	49793	81547
0.50%	Frequency	1126	512	2032	2734	3675	3068	4384	9658	20681	24315
1.00%	Frequency	798	289	1323	1522	2268	1723	2812	4333	13258	11753
2.00%	Frequency	373	156	919	991	904	879	1142	2281	9449	6111
5.00%	Frequency	85	46	219	305	220	217	458	731	3394	2144
0.15%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
0.50%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
1.00%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
2.00%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
5.00%	Minimum	5.30	5.30	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
0.15%	Maximum	13.74	11.85	12.11	13.53	13.30	12.42	14.30	13.61	14.54	16.17
0.50%	Maximum	13.85	12.03	12.68	13.66	13.12	12.99	13.60	14.12	14.57	16.18
1.00%	Maximum	14.21	12.04	12.64	13.81	13.29	13.01	14.00	14.30	14.55	16.18
2.00%	Maximum	14.71	12.04	12.65	13.94	13.13	12.66	14.00	14.23	14.61	16.22
5.00%	Maximum	14.95	12.12	12.69	13.13	13.16	12.13	14.20	14.71	14.63	15.56
0.15%	Standard Deviation	1.85	1.39	1.48	1.54	1.54	1.59	1.67	1.64	1.76	1.88
0.50%	Standard Deviation	2.25	1.50	1.62	1.71	1.63	1.75	1.85	1.74	1.91	2.02
1.00%	Standard Deviation	2.39	1.54	1.68	1.81	1.66	1.85	1.91	1.79	1.99	2.18
2.00%	Standard Deviation	2.41	1.67	1.71	1.82	1.71	1.85	1.98	1.84	2.04	2.35
5.00%	Standard Deviation	2.33	1.73	1.59	1.83	1.83	1.78	2.15	1.76	2.12	2.39

Table 2 Continued

Summary statistics are computed for VNET across four two-week trading periods using five different threshold returns (0.15%,0.5%,1%,2%,5%). Firms are placed into deciles by ranking according to total monthly trading volume in December 1998 for NYSE listed companies.

$VNET_{j,k} = \log\left|\sum_i \left(d^k_{i,j} \times vol^k_{i,j}\right)\right|$ where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each j th duration for company k.

2002		Low Volume				Decile					High Volume
Threshold		0	1	2	3	4	5	6	7	8	9
0.15%	Mean	6.64	7.10	6.79	6.61	6.95	6.59	7.09	7.01	7.22	7.67
0.50%	Mean	7.09	7.37	7.32	6.85	7.48	6.81	7.53	7.83	7.82	8.73
1.00%	Mean	7.38	7.24	7.48	6.99	7.83	7.01	7.64	8.31	8.17	9.48
2.00%	Mean	7.60	7.30	7.90	7.36	7.96	7.35	8.07	8.62	8.45	10.18
5.00%	Mean	8.11	7.64	9.01	8.33	7.72	7.66	8.79	9.28	10.40	11.20
0.15%	Frequency	9747	1554	6408	15772	15811	22535	18404	40831	76280	153895
0.50%	Frequency	7265	645	3410	10893	7665	15648	8683	14322	36333	52555
1.00%	Frequency	4638	409	2558	7983	4783	11173	5859	7468	23345	23583
2.00%	Frequency	2484	244	1384	4189	2832	5961	2965	4474	14894	10553
5.00%	Frequency	704	95	360	1030	1639	2385	1069	1606	2737	3144
0.15%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
0.50%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
1.00%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
2.00%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
5.00%	Minimum	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
0.15%	Maximum	13.46	12.19	12.41	13.32	14.35	13.06	14.12	14.54	15.10	15.04
0.50%	Maximum	13.46	12.48	12.91	13.55	14.35	13.29	14.35	14.55	15.07	15.09
1.00%	Maximum	13.74	12.56	12.83	13.35	14.94	13.25	14.77	14.60	15.07	15.09
2.00%	Maximum	14.25	12.58	13.10	13.39	15.05	13.81	14.77	14.56	15.05	15.06
5.00%	Maximum	14.76	11.40	13.13	13.40	14.32	14.03	14.78	14.85	14.99	15.30
0.15%	Standard Deviation	1.49	1.51	1.53	1.49	1.66	1.51	1.66	1.58	1.70	1.83
0.50%	Standard Deviation	1.63	1.77	1.60	1.56	1.87	1.58	1.68	1.73	1.83	1.94
1.00%	Standard Deviation	1.69	1.77	1.63	1.60	1.95	1.62	1.72	1.83	1.88	1.93
2.00%	Standard Deviation	1.87	1.71	1.64	1.65	2.07	1.68	1.73	1.98	1.93	1.92
5.00%	Standard Deviation	1.97	1.55	1.68	1.67	1.93	1.79	1.74	2.10	1.72	1.80

Table 3: VNET Summary Statistics by Trading Volume Ranked Deciles for Nasdaq

Summary statistics are computed for VNET across four two-week trading periods using five different threshold returns (0.15%,0.5%,1%,2%,5%). Firms are placed into deciles by ranking according to total monthly trading volume in March 1999 for Nasdaq listed companies.

$$VNET_{j,k} = \log\left|\sum_i \left(d^k_{i,j} \times vol^k_{i,j}\right)\right|$$

where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each j th duration for company k.

1999		Low Volume				Decile				High Volume	
Threshold		0	1	2	3	4	5	6	7	8	9
0.15%	Mean	6.60	6.80	6.82	6.92	7.06	7.21	7.28	7.15	7.42	8.72
0.50%	Mean	6.94	7.12	7.20	7.37	7.38	7.71	7.77	7.99	8.50	9.83
1.00%	Mean	7.50	7.40	7.44	7.90	7.91	8.25	8.26	8.66	9.26	10.46
2.00%	Mean	8.00	7.71	7.86	8.31	8.48	8.83	8.95	9.33	9.82	11.03
5.00%	Mean	8.12	8.28	8.67	9.32	9.41	9.59	9.94	10.43	10.50	11.79
0.15%	Frequency	941	1233	2130	2044	3170	6165	4570	12403	14427	12441
0.50%	Frequency	608	753	1205	1074	1878	3049	2036	3882	3375	2094
1.00%	Frequency	294	433	697	486	834	1298	910	1524	1139	700
2.00%	Frequency	128	162	314	205	299	455	336	521	352	208
5.00%	Frequency	25	42	72	37	64	85	74	98	55	23
0.15%	Minimum	4.61	3.40	3.00	2.64	2.30	2.89	1.79	0.69	1.39	1.10
0.50%	Minimum	3.22	3.40	4.32	1.95	1.61	0.69	2.64	1.61	0.69	1.61
1.00%	Minimum	3.22	3.22	3.91	2.64	2.30	2.40	3.91	2.77	3.22	3.00
2.00%	Minimum	4.43	3.58	3.91	4.34	3.91	2.83	4.61	3.22	3.33	5.50
5.00%	Minimum	5.16	6.40	4.62	6.40	5.86	4.61	5.86	7.54	6.54	6.55
0.15%	Maximum	11.56	11.43	11.19	12.29	11.56	12.79	13.40	12.66	12.59	14.98
0.50%	Maximum	11.56	11.43	11.02	12.30	11.45	13.22	13.88	12.72	13.03	14.30
1.00%	Maximum	11.72	11.36	11.34	12.37	11.64	13.80	14.13	12.65	13.26	14.82
2.00%	Maximum	11.57	10.76	10.97	11.21	11.73	13.81	13.12	12.68	13.27	14.62
5.00%	Maximum	9.51	10.29	10.73	11.38	11.75	12.74	13.08	12.57	13.29	15.13
0.15%	Standard Deviation	1.43	1.34	1.35	1.49	1.48	1.47	1.51	1.52	1.55	1.83
0.50%	Standard Deviation	1.54	1.36	1.34	1.53	1.52	1.51	1.55	1.54	1.56	1.88
1.00%	Standard Deviation	1.60	1.40	1.38	1.48	1.52	1.48	1.51	1.44	1.46	1.81
2.00%	Standard Deviation	1.59	1.40	1.33	1.52	1.40	1.61	1.40	1.43	1.53	1.77
5.00%	Standard Deviation	1.21	0.93	1.20	1.21	1.27	1.51	1.36	1.15	1.64	2.18

Table 3 Continued

Summary statistics are computed for VNET across four two-week trading periods using five different threshold returns (0.15%,0.5%,1%,2%,5%). Firms are placed into deciles by ranking according to total monthly trading volume in March 1999 for Nasdaq listed companies.

$$VNET_{j,k} = \log\left|\sum_i \left(d^k_{i,j} \times vol^k_{i,j}\right)\right|$$

where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each j th duration for company k.

2001 Threshold	Pre-Decimalization	Low Volume 0	1	2	3	Decile 4	5	6	7	8	High Volume 9
0.15%	Mean	6.12	6.42	6.67	7.05	6.58	7.08	6.81	7.54	7.66	9.45
0.50%	Mean	6.51	6.92	7.22	7.58	7.32	7.94	7.38	8.06	8.83	10.70
1.00%	Mean	6.89	7.49	7.59	7.94	7.75	8.45	7.82	8.49	9.66	11.27
2.00%	Mean	7.23	7.97	8.05	8.26	8.32	9.09	8.47	8.99	10.31	11.65
5.00%	Mean	7.69	8.56	8.52	8.48	8.87	9.91	9.20	9.64	11.03	12.16
0.15%	Frequency	1556	3407	4470	8237	8379	13102	5706	11194	21487	11950
0.50%	Frequency	850	1529	1678	2204	2976	3890	1934	3249	4807	2119
1.00%	Frequency	471	711	819	932	1336	1759	843	1339	1685	706
2.00%	Frequency	203	300	369	330	513	607	330	512	529	215
5.00%	Frequency	53	62	101	73	111	116	58	108	89	27
0.15%	Minimum	2.30	2.71	1.10	1.61	2.56	2.30	1.61	1.79	1.39	0.69
0.50%	Minimum	3.91	3.00	3.00	1.61	2.40	2.08	1.61	1.61	1.39	3.61
1.00%	Minimum	3.00	4.61	2.30	3.91	2.77	2.30	2.64	4.09	3.74	4.61
2.00%	Minimum	3.00	4.61	3.71	4.61	2.71	4.61	3.30	4.22	3.81	4.61
5.00%	Minimum	4.61	4.61	4.61	3.91	4.61	4.36	5.70	3.91	6.15	8.30
0.15%	Maximum	10.82	12.73	12.72	12.38	13.32	13.35	12.65	14.10	13.84	15.82
0.50%	Maximum	11.24	12.85	12.96	12.49	13.34	13.31	11.93	14.21	14.06	15.55
1.00%	Maximum	11.22	12.25	12.95	13.29	13.30	13.58	12.06	14.88	14.24	15.87
2.00%	Maximum	10.85	12.21	12.96	13.80	13.68	13.36	12.33	14.91	14.27	16.32
5.00%	Maximum	10.88	12.64	12.98	12.82	12.76	13.52	11.75	14.61	14.50	15.91
0.15%	Standard Deviation	1.35	1.54	1.64	1.58	1.55	1.61	1.63	1.80	1.73	2.14
0.50%	Standard Deviation	1.43	1.55	1.75	1.75	1.69	1.69	1.66	1.97	1.75	2.02
1.00%	Standard Deviation	1.50	1.73	1.81	1.75	1.72	1.70	1.69	2.02	1.70	2.10
2.00%	Standard Deviation	1.51	1.56	1.83	1.75	1.73	1.68	1.58	2.00	1.85	2.15
5.00%	Standard Deviation	1.41	1.51	1.76	1.63	1.71	1.43	1.41	2.16	1.74	2.11

Table 3 Continued

Summary statistics are computed for VNET across four two-week trading periods using five different threshold returns (0.15%,0.5%,1%,2%,5%). Firms are placed into deciles by ranking according to total monthly trading volume in March 1999 for Nasdaq listed companies.

$$VNET_{j,k} = \log\left|\sum_i \left(d_{i,j}^k \times vol_{i,j}^k\right)\right|$$

where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each j th duration for company k.

2001 Post-Decimalization		Low Volume				Decile					High Volume
Threshold		0	1	2	3	4	5	6	7	8	9
0.15%	Mean	6.30	6.06	6.65	7.16	6.91	7.13	6.93	7.63	7.97	9.44
0.50%	Mean	6.75	6.67	7.24	7.91	7.68	8.05	7.44	8.17	9.20	10.68
1.00%	Mean	7.17	7.07	7.52	8.25	8.30	8.68	7.84	8.57	9.89	11.27
2.00%	Mean	7.38	7.80	7.80	8.60	8.68	9.34	8.30	9.05	10.63	11.75
5.00%	Mean	7.64	8.38	8.15	8.93	9.61	10.15	8.91	9.64	11.78	12.52
0.15%	Frequency	2293	3833	4025	7883	7856	11346	5280	11996	18585	10052
0.50%	Frequency	1055	1589	1421	1917	2539	3159	1896	3345	3732	1527
1.00%	Frequency	576	824	736	768	1109	1205	829	1358	1181	453
2.00%	Frequency	249	346	320	276	413	434	328	446	323	127
5.00%	Frequency	65	58	73	51	82	76	63	96	37	13
0.15%	Minimum	3.91	2.30	0.69	1.79	2.71	3.00	1.10	0.69	0.69	0.69
0.50%	Minimum	3.33	2.48	3.53	1.61	1.61	2.77	4.25	2.83	0.69	4.61
1.00%	Minimum	3.91	2.30	3.91	3.00	3.33	4.61	3.91	1.61	1.39	4.38
2.00%	Minimum	3.91	1.61	3.91	4.61	4.32	4.61	3.58	4.61	4.60	4.61
5.00%	Minimum	4.61	4.61	4.61	5.30	4.61	6.68	4.61	5.92	8.12	10.55
0.15%	Maximum	11.92	12.36	13.03	12.97	13.82	13.80	12.44	13.38	14.22	15.01
0.50%	Maximum	12.25	12.36	12.98	12.95	13.86	13.95	12.49	13.77	14.28	15.50
1.00%	Maximum	12.26	12.36	13.11	13.16	13.85	14.05	13.07	13.78	14.41	15.66
2.00%	Maximum	12.23	12.35	12.94	13.58	13.87	14.04	12.57	14.12	14.42	15.25
5.00%	Maximum	11.89	12.19	11.14	11.76	13.89	14.01	12.01	13.80	15.30	14.33
0.15%	Standard Deviation	1.47	1.37	1.58	1.55	1.61	1.61	1.60	1.70	1.68	1.95
0.50%	Standard Deviation	1.60	1.47	1.68	1.74	1.69	1.68	1.66	1.84	1.72	1.91
1.00%	Standard Deviation	1.74	1.56	1.71	1.82	1.68	1.68	1.68	1.89	1.78	1.97
2.00%	Standard Deviation	1.83	1.64	1.71	1.83	1.75	1.58	1.63	1.87	1.72	2.05
5.00%	Standard Deviation	1.82	1.62	1.62	1.62	1.57	1.31	1.76	1.66	1.90	1.14

Table 3 Continued

Summary statistics are computed for VNET across four two-week trading periods using five different threshold returns (0.15%,0.5%,1%,2%,5%). Firms are placed into deciles by ranking according to total monthly trading volume in March 1999 for Nasdaq listed companies.

$$VNET_{j,k} = \log\left|\sum_i \left(d^k_{i,j} \times vol^k_{i,j}\right)\right|$$

where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each j th duration for company k.

2002		Low Volume				Decile					High Volume
Threshold		0	1	2	3	4	5	6	7	8	9
0.15%	Mean	6.98	6.96	6.96	7.23	6.91	7.18	7.06	7.96	8.17	9.83
0.50%	Mean	7.58	7.59	7.64	7.72	7.63	8.03	7.74	8.43	9.01	11.18
1.00%	Mean	7.68	7.83	8.01	8.03	8.24	8.80	8.29	8.78	9.65	11.85
2.00%	Mean	8.23	7.99	8.51	8.40	8.74	9.22	9.02	9.10	10.21	12.62
5.00%	Mean	8.13	8.42	9.43	8.65	8.95	10.36	9.83	9.72	10.63	13.15
0.15%	Frequency	3656	4075	5348	5646	7872	14237	6901	9701	15504	14898
0.50%	Frequency	1053	1377	1595	1532	2176	3898	2213	2025	3171	2034
1.00%	Frequency	483	556	665	634	853	1544	862	697	1004	606
2.00%	Frequency	203	220	234	239	319	467	235	198	301	176
5.00%	Frequency	51	41	29	47	41	86	29	40	48	21
0.15%	Minimum	1.39	2.77	1.39	0.69	1.61	0.69	2.08	1.61	0.69	2.40
0.50%	Minimum	2.30	0.69	1.10	2.83	0.69	2.08	3.91	3.22	2.08	3.14
1.00%	Minimum	2.64	0.69	4.32	3.93	2.40	3.40	0.69	3.00	3.91	4.61
2.00%	Minimum	4.61	0.69	3.81	4.50	4.61	3.40	4.61	4.22	4.61	5.81
5.00%	Minimum	4.61	5.30	4.61	4.61	5.30	6.49	7.70	5.42	7.00	7.74
0.15%	Maximum	12.77	11.98	13.72	12.58	13.16	15.36	12.66	14.51	13.41	14.90
0.50%	Maximum	13.33	11.98	13.71	12.53	13.17	15.36	13.07	14.51	13.45	15.37
1.00%	Maximum	12.38	12.07	13.28	12.76	13.20	15.36	12.86	14.36	13.98	16.09
2.00%	Maximum	12.52	12.10	13.48	12.05	13.41	15.36	12.50	14.27	13.93	16.17
5.00%	Maximum	10.99	11.56	13.84	11.83	12.22	15.37	12.06	12.81	13.89	16.73
0.15%	Standard Deviation	1.56	1.53	1.64	1.58	1.66	1.57	1.61	1.70	1.59	2.11
0.50%	Standard Deviation	1.74	1.66	1.71	1.76	1.64	1.72	1.68	1.98	1.75	2.15
1.00%	Standard Deviation	1.74	1.72	1.82	1.75	1.69	1.69	1.66	2.01	1.76	2.26
2.00%	Standard Deviation	1.64	1.80	1.82	1.80	1.53	1.75	1.45	1.83	1.68	2.08
5.00%	Standard Deviation	1.45	1.65	2.14	1.80	1.63	1.54	1.06	1.43	1.64	2.50

Tables 4 and 5 convert the VNET statistics presented in Tables 2 and 3 into number of shares. VNET is converted into shares by computing the antilogarithm of the reported VNET statistic. For instance, in Table 2, VNET is 6.98 for the low volume (0) decile in 1999 at the 0.15% threshold. Computing $e^{6.98}$, we obtain 1,076 shares, which is reported in Table 4 for the low volume (0) decile at the 0.15% threshold in 1999. During the 1999 trading period, the share volume necessary to induce a price change is higher for the NYSE compared to Nasdaq for most return thresholds across all possible deciles. However, during the 2001 pre-decimalization period, the volume necessary to induce a price change is higher on Nasdaq than on the NYSE for high volume stocks, deciles 8 and 9. During the 2002 period, the share volume necessary to induce a price change is higher on the Nasdaq than on the NYSE for all volume deciles. Therefore, it appears that while the NYSE had more depth in 1999, improvements in depth between 1999 and 2002 result in the Nasdaq sample of firms having higher depth in 2002. Unconditional t-tests of VNET investigate these possible differences in Table 6.

Panel A of Table 6 provides differences in mean VNET values by time period for the NYSE and Nasdaq at the 1% and 2% return thresholds. T-test results for the 1% and 2% thresholds are consistent for both the NYSE and Nasdaq for the time periods presented. Average VNET values increase from 8.4207 to 8.7134 for the Nasdaq 1% from 1999 to 2002 and are statistically different at the 1% level. Therefore, depth

Table 4: Trading Volume Necessary to Induce Price Changes by Trading Volume Ranked Deciles for NYSE

Trading Volume is calculated as: EXPONENTIAL (VNET). VNET is computed and reported in Table 2 for NYSE firms.

$$VNET_{j,k} = \log\left|\sum_i \left(d_{i,j}^k \times vol_{i,j}^k\right)\right|$$

where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each j th duration for company k.

1999		Low Volume				Decile					High Volume
Threshold		0	1	2	3	4	5	6	7	8	9
0.15%	Mean	1076	1438	1262	1287	1245	1690	1668	2055	1689	4218
0.50%	Mean	3032	2922	4077	3683	4430	3482	3859	7081	4268	20154
1.00%	Mean	4509	2712	6092	6117	7948	6606	5148	16593	8291	46024
2.00%	Mean	7674	2922	5696	7240	14237	9959	8990	22434	14174	89954
5.00%	Mean	32651	2841	10008	8414	15286	19985	13921	34003	44561	208770
0.15%	Minimum	100	100	100	100	100	100	100	100	100	100
0.50%	Minimum	100	100	100	100	100	100	100	100	100	100
1.00%	Minimum	100	100	100	100	100	100	100	100	100	100
2.00%	Minimum	100	100	100	100	100	100	100	100	100	100
5.00%	Minimum	4000	1000	200	100	200	300	100	400	300	100
0.15%	Maximum	155200	45000	117000	3805700	254000	1927200	744400	4396200	7502600	3500000
0.50%	Maximum	219000	60000	141400	3805700	898800	2278900	737600	4361000	7498800	5294700
1.00%	Maximum	150200	64700	184500	3806600	547900	1873700	690400	1365400	7524900	5373900
2.00%	Maximum	127700	51200	106700	495700	494800	490500	606000	1110700	7555600	5462500
5.00%	Maximum	113300	15500	81400	340300	127400	548000	483200	626600	11198800	4960500
0.15%	Standard Deviation	3.56	3.63	3.93	4.04	4.60	4.87	4.57	5.03	5.49	6.06
0.50%	Standard Deviation	3.99	4.41	4.55	4.56	5.24	5.93	5.34	5.41	6.59	5.99
1.00%	Standard Deviation	4.24	4.61	4.92	5.13	5.87	6.08	6.75	5.94	6.83	6.01
2.00%	Standard Deviation	3.81	3.72	5.43	6.70	6.27	5.79	7.27	6.49	7.23	6.12
5.00%	Standard Deviation	3.12	3.26	4.60	11.41	5.30	6.92	7.45	9.08	4.71	6.93

Table 4 Continued

Trading Volume is calculated as: EXPONENTIAL (VNET). VNET is computed and reported in Table 2 for NYSE firms.

$$VNET_{j,k} = \log\left|\sum_{i}\left(d^{k}_{i,j} \times vol^{k}_{i,j}\right)\right|$$

where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each j th duration for company k.

2001 Pre-Decimalization		Low Volume				Decile					High Volume
Threshold		0	1	2	3	4	5	6	7	8	9
0.15%	Mean	687	1010	711	802	1062	833	1084	1111	1148	1716
0.50%	Mean	1116	1505	1244	1625	1592	1376	2722	2131	2501	5430
1.00%	Mean	2187	2024	2234	4120	2321	2314	5076	5503	3669	13720
2.00%	Mean	5810	2939	4617	5232	4061	3273	9215	13120	8066	33886
5.00%	Mean	15259	4534	9085	4629	8280	3878	12101	35386	27314	102866
0.15%	Minimum	100	100	100	100	100	100	100	100	100	100
0.50%	Minimum	100	100	100	100	100	100	100	100	100	100
1.00%	Minimum	100	100	100	100	100	100	100	100	100	100
2.00%	Minimum	100	100	100	100	100	100	100	100	100	100
5.00%	Minimum	400	100	100	100	100	100	100	100	100	100
0.15%	Maximum	76000	121400	125200	2092000	2538000	600000	1362800	1774200	3572000	3612000
0.50%	Maximum	152200	119400	144000	2095300	3806000	803000	1383100	3141700	3572000	3840500
1.00%	Maximum	82000	161200	225500	2097300	3806000	870400	1372800	3105200	3572000	3956400
2.00%	Maximum	135200	161200	220600	937600	3805500	1008900	1598500	3153800	3572000	4084400
5.00%	Maximum	118500	309500	181300	414100	3631100	1099000	1421600	2921600	4806300	3990300
0.15%	Standard Deviation	3.85	3.67	3.62	4.10	4.56	4.10	4.66	4.38	5.05	6.00
0.50%	Standard Deviation	4.26	4.12	4.09	4.77	5.14	4.68	5.59	5.14	5.89	6.89
1.00%	Standard Deviation	4.36	4.44	4.60	5.31	5.95	5.30	6.21	5.88	6.20	6.91
2.00%	Standard Deviation	4.80	5.29	4.99	7.58	7.32	5.38	6.83	6.59	6.27	7.14
5.00%	Standard Deviation	3.80	5.90	6.89	8.78	8.23	6.48	9.87	5.92	6.95	7.08

Table 4 Continued

Trading Volume is calculated as: EXPONENTIAL (VNET). VNET is computed and reported in Table 2 for NYSE firms.

$$VNET_{j,k} = \log\left|\sum_{i}\left(d_{i,j}^{k} \times vol_{i,j}^{k}\right)\right|$$

where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each j th duration for company k.

2001	Post-Decimalization	Low Volume				Decile					High Volume
Threshold		0	1	2	3	4	5	6	7	8	9
0.15%	Mean	2209	1670	1017	1600	1513	1234	2141	1552	1865	2988
0.50%	Mean	4954	2272	1617	2269	2706	2210	2916	2988	3518	7813
1.00%	Mean	8487	2654	1813	2757	3375	2905	2774	4735	3945	11121
2.00%	Mean	9085	2546	1831	2581	6315	4004	4546	6007	3766	12963
5.00%	Mean	14512	6151	4322	3422	10009	6587	5556	12637	7392	25847
0.15%	Minimum	100	100	100	100	100	100	100	100	100	100
0.50%	Minimum	100	100	100	100	100	100	100	100	100	100
1.00%	Minimum	100	100	100	100	100	100	100	100	100	100
2.00%	Minimum	100	100	100	100	100	100	100	100	100	100
5.00%	Minimum	200	200	100	100	100	100	100	100	100	100
0.15%	Maximum	924000	139500	181700	748400	599400	246600	1624900	813500	2057700	10497800
0.50%	Maximum	1039500	167600	321700	857700	499400	436900	806600	1353900	2122900	10641200
1.00%	Maximum	1478300	170200	308200	992800	591600	445100	1200900	1623600	2078500	10647700
2.00%	Maximum	2448600	168900	312600	1137100	505300	315000	1200900	1507400	2211500	11085500
5.00%	Maximum	3118500	182600	323600	503900	517200	185100	1470800	2448400	2267400	5730700
0.15%	Standard Deviation	6.35	4.00	4.41	4.65	4.66	4.89	5.29	5.17	5.82	6.54
0.50%	Standard Deviation	9.45	4.49	5.07	5.54	5.11	5.78	6.35	5.71	6.74	7.53
1.00%	Standard Deviation	10.92	4.67	5.37	6.08	5.27	6.35	6.74	6.00	7.32	8.81
2.00%	Standard Deviation	11.17	5.33	5.55	6.17	5.51	6.37	7.25	6.31	7.71	10.49
5.00%	Standard Deviation	10.31	5.64	4.92	6.22	6.22	5.93	8.56	5.80	8.30	10.89

Table 4 Continued

Trading Volume is calculated as: EXPONENTIAL (VNET). VNET is computed and reported in Table 2 for NYSE firms.

$$VNET_{j,k} = \log\left|\sum_i \left(d^k_{i,j} \times vol^k_{i,j}\right)\right|$$

where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each j th duration for company k.

2002		Low Volume				Decile					High Volume
Threshold		0	1	2	3	4	5	6	7	8	9
0.15%	Mean	762	1213	888	744	1045	726	1205	1105	1363	2135
0.50%	Mean	1199	1596	1511	945	1778	907	1862	2512	2492	6210
1.00%	Mean	1600	1400	1769	1085	2511	1109	2086	4056	3544	13092
2.00%	Mean	2007	1478	2708	1566	2852	1562	3193	5558	4668	26491
5.00%	Mean	3332	2088	8218	4149	2258	2112	6542	10744	32894	73080
0.15%	Minimum	100	100	100	100	100	100	100	100	100	100
0.50%	Minimum	100	100	100	100	100	100	100	100	100	100
1.00%	Minimum	100	100	100	100	100	100	100	100	100	100
2.00%	Minimum	100	100	100	100	100	100	100	100	100	100
5.00%	Minimum	100	100	100	100	100	100	100	100	100	100
0.15%	Maximum	697900	197400	245400	609900	1700000	470400	1361900	2061400	3601400	3408700
0.50%	Maximum	699400	262900	403000	765100	1700000	594000	1708600	2080300	3515700	3589400
1.00%	Maximum	928800	285600	371400	626300	3073400	567000	2601600	2196500	3511300	3573400
2.00%	Maximum	1537900	290200	489400	654000	3422000	997800	2601600	2107200	3436400	3477300
5.00%	Maximum	2565400	89100	502900	661200	1648100	1244600	2627700	2808100	3221200	4432400
0.15%	Standard Deviation	4.43	4.50	4.61	4.42	5.28	4.54	5.24	4.83	5.46	6.22
0.50%	Standard Deviation	5.13	5.84	4.95	4.75	6.47	4.86	5.36	5.62	6.24	6.94
1.00%	Standard Deviation	5.44	5.88	5.09	4.96	7.01	5.06	5.60	6.26	6.59	6.87
2.00%	Standard Deviation	6.46	5.51	5.14	5.22	7.94	5.34	5.62	7.23	6.87	6.81
5.00%	Standard Deviation	7.15	4.69	5.39	5.32	6.86	6.01	5.70	8.15	5.57	6.02

Table 5: Trading Volume Necessary to Induce Price Changes by Trading Volume Ranked Deciles for Nasdaq

Trading Volume is calculated as: EXPONENTIAL (VNET). VNET is computed and reported in Table 3 for Nasdaq firms.

$$VNET_{j,k} = \log\left|\sum_i \left(d_{i,j}^k \times vol_{i,j}^k\right)\right|$$

where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each j th duration for company k.

1999		Low Volume				Decile					High Volume
Threshold		0	1	2	3	4	5	6	7	8	9
0.15%	Mean	733	901	912	1010	1165	1358	1450	1272	1675	6121
0.50%	Mean	1036	1239	1335	1585	1599	2237	2379	2965	4935	18625
1.00%	Mean	1803	1629	1705	2688	2731	3814	3881	5770	10513	34954
2.00%	Mean	2987	2239	2589	4045	4794	6855	7699	11216	18315	61754
5.00%	Mean	3346	3956	5809	11213	12215	14588	20801	34030	36459	132533
0.15%	Minimum	100	30	20	14	10	18	6	2	4	3
0.50%	Minimum	25	30	75	7	5	2	14	5	2	5
1.00%	Minimum	25	25	50	14	10	11	50	16	25	20
2.00%	Minimum	84	36	50	77	50	17	100	25	28	244
5.00%	Minimum	175	600	101	600	350	100	351	1875	692	701
0.15%	Maximum	105000	91600	72500	217114	104800	357400	660400	315228	292810	3191196
0.50%	Maximum	105000	91600	61140	220189	93800	554000	1063450	333913	455101	1622613
1.00%	Maximum	123300	85780	84084	236189	113200	988713	1369250	310750	572975	2742322
2.00%	Maximum	105561	47100	57845	73689	124628	989613	499600	321075	578011	2228322
5.00%	Maximum	13440	29366	45700	87289	126432	342071	480600	287655	590925	3732607
0.15%	Standard Deviation	4.19	3.81	3.86	4.44	4.40	4.34	4.54	4.57	4.71	6.24
0.50%	Standard Deviation	4.65	3.88	3.83	4.63	4.57	4.52	4.71	4.65	4.77	6.54
1.00%	Standard Deviation	4.96	4.04	3.99	4.38	4.55	4.39	4.52	4.23	4.31	6.12
2.00%	Standard Deviation	4.92	4.05	3.80	4.58	4.06	5.00	4.06	4.17	4.61	5.89
5.00%	Standard Deviation	3.37	2.52	3.33	3.35	3.56	4.52	3.90	3.16	5.13	8.88

Table 5 Continued

Trading Volume is calculated as: EXPONENTIAL (VNET). VNET is computed and reported in Table 3 for Nasdaq firms.

$$VNET_{j,k} = \log\left|\sum_i \left(d_{i,j}^k \times vol_{i,j}^k\right)\right|$$

where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each j th duration for company k.

2001 Threshold	Pre-Decimalization	Low Volume 0	1	2	3	Decile 4	5	6	7	8	High Volume 9
0.15%	Mean	456	611	787	1154	718	1188	909	1888	2127	12716
0.50%	Mean	671	1013	1360	1965	1503	2803	1600	3170	6818	44450
1.00%	Mean	981	1793	1982	2816	2333	4678	2500	4879	15704	78146
2.00%	Mean	1380	2884	3134	3871	4112	8906	4781	8019	29944	114223
5.00%	Mean	2190	5219	5014	4820	7085	20155	9882	15362	61428	191467
0.15%	Minimum	10	15	3	5	13	10	5	6	4	2
0.50%	Minimum	50	20	20	5	11	8	5	5	4	37
1.00%	Minimum	20	100	10	50	16	10	14	60	42	100
2.00%	Minimum	20	100	41	100	15	100	27	68	45	100
5.00%	Minimum	100	100	100	50	100	78	300	50	469	4009
0.15%	Maximum	49900	336800	335200	237800	609200	625000	311497	1333609	1026058	7403672
0.50%	Maximum	75800	381830	425475	266239	618700	604742	151848	1481132	1272725	5659405
1.00%	Maximum	74900	208000	421475	591083	597700	789311	172350	2895253	1532129	7841348
2.00%	Maximum	51300	201000	424075	979933	871649	636365	226734	2987537	1570094	12224647
5.00%	Maximum	53266	308049	433875	371189	347388	743119	126137	2207815	1980995	8120165
0.15%	Standard Deviation	3.85	4.68	5.17	4.85	4.72	5.01	5.10	6.07	5.65	8.52
0.50%	Standard Deviation	4.16	4.73	5.77	5.75	5.43	5.40	5.24	7.20	5.76	7.51
1.00%	Standard Deviation	4.46	5.65	6.09	5.78	5.58	5.45	5.43	7.51	5.47	8.17
2.00%	Standard Deviation	4.54	4.78	6.26	5.75	5.65	5.35	4.87	7.36	6.38	8.56
5.00%	Standard Deviation	4.11	4.54	5.81	5.08	5.53	4.17	4.09	8.71	5.68	8.22

Table 5 Continued

Trading Volume is calculated as: EXPONENTIAL (VNET). VNET is computed and reported in Table 3 for Nasdaq firms.

$$VNET_{j,k} = \log\left|\sum_i \left(d_{i,j}^k \times vol_{i,j}^k\right)\right|$$

where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each j th duration for company k.

2001 Threshold	Post-Decimalization	Low Volume 0	1	2	3	Decile 4	5	6	7	8	High Volume 9
0.15%	Mean	544	428	769	1282	1002	1250	1021	2060	2902	12628
0.50%	Mean	851	789	1390	2727	2175	3126	1704	3542	9859	43393
1.00%	Mean	1302	1179	1839	3834	4025	5876	2545	5246	19731	78110
2.00%	Mean	1605	2448	2436	5453	5858	11384	4040	8548	41524	126767
5.00%	Mean	2072	4352	3475	7582	14885	25649	7418	15310	131218	273424
0.15%	Minimum	50	10	2	6	15	20	3	2	2	2
0.50%	Minimum	28	12	34	5	5	16	70	17	2	100
1.00%	Minimum	50	10	50	20	28	100	50	5	4	80
2.00%	Minimum	50	5	50	100	75	100	36	100	99	100
5.00%	Minimum	100	100	100	200	100	800	100	372	3360	38226
0.15%	Maximum	150300	233017	456000	429000	1004350	983600	251475	649200	1501650	3299876
0.50%	Maximum	209200	233017	433810	419744	1040530	1145875	265909	959900	1595306	5387289
1.00%	Maximum	211500	233017	492600	519469	1039630	1269412	472186	965200	1819101	6310533
2.00%	Maximum	204000	232017	416120	793945	1054735	1250807	288423	1358128	1832803	4179532
5.00%	Maximum	145200	195850	69200	128214	1078895	1218353	163965	988700	4423834	1678138
0.15%	Standard Deviation	4.34	3.95	4.87	4.72	4.98	4.99	4.94	5.46	5.36	7.04
0.50%	Standard Deviation	4.97	4.37	5.36	5.72	5.40	5.35	5.25	6.32	5.57	6.73
1.00%	Standard Deviation	5.71	4.75	5.50	6.18	5.38	5.34	5.35	6.63	5.91	7.14
2.00%	Standard Deviation	6.26	5.16	5.51	6.23	5.78	4.84	5.10	6.52	5.61	7.74
5.00%	Standard Deviation	6.17	5.08	5.04	5.07	4.79	3.69	5.83	5.28	6.66	3.12

Table 5 Continued

Trading Volume is calculated as: EXPONENTIAL (VNET). VNET is computed and reported in Table 3 for Nasdaq firms.

$$VNET_{j,k} = \log\left|\sum_i \left(d^k_{i,j} \times vol^k_{i,j}\right)\right|$$

where, d is the trade direction indicator (buy= 1, sell= -1) and vol is the number of shares traded. VNET is computed for each j th duration for company k.

2002		Low Volume				Decile					High Volume
Threshold		0	1	2	3	4	5	6	7	8	9
0.15%	Mean	1078	1052	1058	1379	1001	1316	1166	2860	3526	18501
0.50%	Mean	1951	1979	2070	2254	2052	3071	2303	4565	8187	71338
1.00%	Mean	2165	2517	3016	3062	3800	6607	3986	6507	15565	140727
2.00%	Mean	3760	2942	4981	4455	6221	10053	8308	8984	27138	303637
5.00%	Mean	3388	4527	12411	5737	7714	31637	18505	16658	41502	513439
0.15%	Minimum	4	16	4	2	5	2	8	5	2	11
0.50%	Minimum	10	2	3	17	2	8	50	25	8	23
1.00%	Minimum	14	2	75	51	11	30	2	20	50	100
2.00%	Minimum	100	2	45	90	100	30	100	68	100	334
5.00%	Minimum	100	200	100	100	200	660	2200	227	1100	2300
0.15%	Maximum	350100	159300	908500	290981	519000	4701010	315855	1995599	669600	2968227
0.50%	Maximum	615219	158878	896979	276927	523000	4701410	472980	2010036	691362	4751168
1.00%	Maximum	237598	174594	584420	348764	541384	4707010	382933	1723400	1177307	9682719
2.00%	Maximum	274641	180000	714520	171131	667642	4694521	268527	1575804	1120783	10553814
5.00%	Maximum	59500	104715	1028548	137732	202969	4750386	173282	364896	1080056	18463080
0.15%	Standard Deviation	4.77	4.61	5.18	4.88	5.24	4.81	5.02	5.47	4.90	8.25
0.50%	Standard Deviation	5.69	5.28	5.51	5.80	5.18	5.57	5.39	7.28	5.76	8.57
1.00%	Standard Deviation	5.70	5.58	6.15	5.74	5.44	5.45	5.27	7.43	5.80	9.58
2.00%	Standard Deviation	5.14	6.02	6.15	6.06	4.64	5.77	4.28	6.20	5.37	7.99
5.00%	Standard Deviation	4.28	5.19	8.51	6.07	5.10	4.64	2.90	4.20	5.17	12.19

Table 6: Unconditional Tests of VNET

Panel A

Unconditional t-tests are employed to test for differences of mean VNET values between samples. Differences in mean VNET values are tested by comparing 1999 values with 2002 values, Pre-Decimalization 2001 with Post-Decimalization values, and Pre-Decimalization 2001 with 2002 values for two return thresholds (1.00% and 2.00%).

	Threshold	1999 Mean	2002 Mean	t-Value	p-Value	Observations
Nasdaq	1.00%	8.4207	8.7134	10.12	0.0001	17697
Nasdaq	2.00%	8.8685	9.0785	4.51	0.0001	7819
NYSE	1.00%	9.3369	8.1468	-61.99	0.0001	159341
NYSE	2.00%	9.6826	8.4771	-37.34	0.0001	83147

	Threshold	Pre-2001 Mean	Post-2001 Mean	t-Value	p-Value	Observations
Nasdaq	1.00%	8.4144	8.4112	-0.02	0.9822	29079
Nasdaq	2.00%	8.8144	8.7386	-1.45	0.1461	10213
NYSE	1.00%	8.5558	8.5101	-3.21	0.0013	167033
NYSE	2.00%	9.2746	8.5760	-36.83	0.0001	74826

	Threshold	Pre-2001 Mean	2002 Mean	t-Value	p-Value	Observations
Nasdaq	1.00%	8.4144	8.7134	9.92	0.0001	23236
Nasdaq	2.00%	8.8144	9.0785	5.36	0.0001	9751
NYSE	1.00%	8.5558	8.1468	-41.21	0.0001	251120
NYSE	2.00%	9.2746	8.4771	-50.44	0.0001	117321

Table 6 Continued

Panel B

Unconditional t-tests are employed to test for differences of mean VNET values between samples. Differences in mean VNET values are tested by comparing mean VNET values for Low Threshold returns and High Threshold returns (1.00% and 2.00%). T-tests are computed separately for 1999, Pre-Decimalization 2001, Post-Decimalization 2001, and 2002 for both the NYSE and Nasdaq.

	Low Threshold (1.00%)	High Threshold (2.00%)			
1999	Mean	Mean	t-Value	p-Value	Observations
Nasdaq	8.4207	8.8685	-12.95	0.0001	13304
NYSE	9.3369	9.6826	-10.37	0.0001	19994

	Low Threshold	High Threshold			
Pre-2001	Mean	Mean	t-Value	p-Value	Observations
Nasdaq	8.4144	8.8144	-11.01	0.0001	20775
NYSE	8.5558	9.2746	-51.05	0.0001	145947

	Low Threshold	High Threshold			
Post-2001	Mean	Mean	t-Value	p-Value	Observations
Nasdaq	8.4112	8.7386	-8.57	0.0001	18517
NYSE	8.5101	8.5760	-4.24	0.0001	95912

	Low Threshold	High Threshold			
2002	Mean	Mean	t-Value	p-Value	Observations
Nasdaq	8.7134	9.0785	-8.48	0.0001	12212
NYSE	8.1468	8.4771	-29.42	0.0001	222494

Table 6 Continued

Panel C

Unconditional t-tests are employed to test for differences of mean VNET values between samples. Differences in mean VNET values are tested by comparing mean VNET values for Nasdaq and NYSE firms. VNET is determined using Low Threshold returns and High Threshold returns (1.00% and 2.00%). T-tests are computed separately for 1999, Pre-Decimalization 2001, Post-Decimalization 2001, and 2002 time periods.

	Threshold	NYSE Mean	Nasdaq Mean	t-Value	p-Value	Observations
1999	1.00%	9.3369	8.4207	-34.03	0.0001	24642
Pre-2001	1.00%	8.5558	8.4144	-5.72	0.0001	121960
Post-2001	1.00%	8.5101	8.4112	-3.22	0.0013	74152
2002	1.00%	8.1468	8.7134	25.22	0.0001	152396

	Threshold	NYSE Mean	Nasdaq Mean	t-Value	p-Value	Observations
1999	2.00%	9.6826	8.8685	-17.75	0.0001	8656
Pre-2001	2.00%	9.2746	8.8144	-12.06	0.0001	44762
Post-2001	2.00%	8.5760	8.7386	5.12	0.0001	40277
2002	2.00%	8.4771	9.0785	15.63	0.0001	82310

increased on Nasdaq from 1999 to 2002. Comparatively, average VNET values decrease from 9.3369 to 8.1468 for the NYSE 1% threshold, showing a drop in depth on the NYSE from 1999 to 2002.

A t-test of average VNET values using the pre-decimalization 2001 and post-decimalization 2001 samples shows the impact of decimalization on depth. Mean VNET values drop from 9.2746 to 8.5760 for the NYSE 2% threshold upon the move to trading in decimals and are statistically different at the 0.01 level of significance. Converting these VNET values to share amounts demonstrates the economic significance of the changes from pre-decimalization to post-decimalization; 10,664 shares were needed to induce a 2% return during the pre-decimalization 2001 period, but only 5,303 shares were needed during the post-decimalization 2001 period. Similar tests for the Nasdaq result in insignificant decreases in VNET. Consequently, decimalization was associated with a significant decrease in depth on the NYSE, but did not significantly affect depth on the Nasdaq.

Unconditional t-tests for the differences in mean VNET values between the 1% threshold and the 2% threshold are presented in panel B of Table 6. The volume necessary to induce a price change is higher for the 2% return threshold than the 1% return threshold for all time periods for both the NYSE and Nasdaq. Consistently, greater share volumes are needed to induce larger price changes or returns.

Unconditional t-tests for differences in mean VNET values between the NYSE and Nasdaq are reported in panel C of Table 6. Average VNET values are statistically different between the NYSE and Nasdaq at the 0.01 level for all time periods and thresholds. The differences in mean values confirm earlier evidence, showing that while depth on the NYSE is higher for the 1999 period, depth on Nasdaq is higher for the 2002 period

3B. Multivariate Results

Table 7 reports regression results for VNET on the NYSE and Nasdaq using the 1% price threshold. The estimates in panel A show that the NYSE sample of firms has greater depth compared to the Nasdaq from 1999 through 2002, with VNET increasing by 0.8261 at the 0.01 level of significance. Consistent with the findings of Engle and Lange (2001), volume, the number of trades, the conditional forecast of time between price changes, and the error in the forecast of time between price changes are associated with increased depth, while higher spreads decrease depth.

Panel B of Table 7 reports the regression results where binary variables for three of the four time periods are added to capture changes in depth through time. Binary variables for 9 of the 10 volume deciles are included to capture differences in volume across deciles. The volume variable is dropped to avoid multicollinearity problems between the volume binaries and the absolute level of volume. Interaction variables between the time periods and exchange listing are included to investigate possible differences in changes of depth through time between the NYSE and Nasdaq.

The binaries for the pre-decimalization 2001, post-decimalization 2001, and 2002 periods show an increase in depth relative to the 1999 time period. The coefficients increase from 0.2793 for the pre-decimalization 2001 period to 0.3639 for the post-decimalization 2001 period. Additionally, the coefficient for the post 2002 period

Table 7: Regression Results for VNET on the NYSE and Nasdaq using 1% Price Threshold

The following regression model is estimated in which the dependent variable is VNET, and the independent variables are the lagged time-weighted average bid-ask spread, the lagged natural logarithm of trade volume, the lagged natural logarithm of the number of trades, the natural logarithm of the forecast of eptime, the error from the forecast of eptime, and a binary variable set to one if the company is NYSE listed. The results are reported in Panel A. The regression model is:

$$VNET_{it} = \alpha + \beta_1 TWASpread_{it-1} + \beta_2 Vol_{it-1} + \beta_3 Trades_{it-1} + \beta_4 Eptime_{it} + \beta_5 Ptime\_err_{it} + \beta_6 NYSE_i + \varepsilon_{it} \quad (1)$$

The results in Panel B are from equation (2), where binary variables have been added for the time period from which the observation originated and interaction terms between the time period binaries and NYSE listing binary. Binary variables for the decile rankings of the number of shares traded are also included. Deciles are ranked from lowest (0) to highest (9) volumes. P-values are reported in parentheses.

$$VNET_{it} = \alpha + \beta_1 TWASpread_{it-1} + \beta_2 Trades_{it-1} + \beta_3 EPtime_{it} + \beta_4 Ptime\_err_{it} + \beta_5 NYSE_i + \beta_6 Pre2001_i + \beta_7 Post2001_i + \beta_8 Post2002_i + \beta_9 Pre2001NYSE_i + \beta_{10} Post2001NYSE_i + \beta_{11} Post2002NYSE_i + \beta_{12} Decile1_i + \beta_{13} Decile2_i + \beta_{14} Decile3_i + \beta_{15} Decile4_i + \beta_{16} Decile5_i + \beta_{17} Decile6_i + \beta_{18} Decile7_i + \beta_{19} Decile8_i + \beta_{20} Decile9_i + \varepsilon_{it} \quad (2)$$

Panel A: VNET on the NYSE and Nasdaq (N=38724)

Intercept	TWASpread	Vol	Trades	Eptime	Ptime_err	NYSE	Adj. R^2
4.16584	-0.00966	0.27767	0.21946	0.18447	0.28208	0.82614	0.2932
(0.0001)	(0.0014)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	

Panel B: VNET on the NYSE and Nasdaq with Volume Deciles (N=38724)

Intercept	TWASpread	Trades	Eptime	Ptime_err	NYSE	Pre2001	Post2001	Post2002
4.8738	-0.0117	0.3398	0.3047	0.3245	1.4258	0.2793	0.3639	0.3755
(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Pre2001NYSE	**Post2001NYSE**	**Post2002NYSE**	**Decile1**	**Decile2**	**Decile3**	**Decile4**	**Decile5**	**Decile6**
-0.4531	-0.5441	-0.6820	-0.2736	0.1039	0.0629	0.2131	0.0013	0.3547
(0.0180)	(0.1444)	(0.3292)	(0.0069)	(0.2400)	(0.4035)	(0.0050)	(0.9857)	(0.0001)
Decile7	**Decile8**	**Decile9**						**Adj. R^2**
0.7090	1.0349	1.7538						0.3150
(0.0001)	(0.0001)	(0.0001)						

increases to 0.3755. The interaction variables between time period and NYSE exchange listing all have negative coefficients. However, only the coefficient of -0.4531 for the pre-decimalization interaction variable is statistically significant at the 0.05 level of significance. Thus, while depth increased on the Nasdaq from 1999 to 2002, it decreased by an insignificant amount on the NYSE over the same time period.

The binary variables for volume rank by decile further show that depth increases as trading volume increases. In particular, the increase in VNET is the largest for the highest volume (9) decile with an increase of 1.7538. Note that the inclusion of the volume decile binaries results in an increase in the coefficient of the NYSE binary to 1.2458. This result suggests it takes about 3.5 more shares of stocks to induce a 1% return for NYSE listed firms compared to Nasdaq listed firms after controlling for all other factors included in this model of depth.

Table 8 provides the regression results for VNET on the NYSE and Nasdaq using the 2% threshold. The explanatory variables are the same as those specified in Table 7, but the threshold for computing VNET is increased from 1% to 2% as a robustness check. A change in the threshold value results in different values for the dependent and independent variables. Some of the signs and statistical significances change from Table 7 to Table 8. In panel A, time-weighted average bid-ask spreads are no longer significantly associated with VNET. In panel B, time-weighted average bid-ask spreads, the time binaries pre-decimalization 2001, post-decimalization 2001, and the volume decile binaries Decile4 and Decile6 become statistically insignificant at the 0.05 level. Furthermore, the coefficients for the volume decile binaries Decile2, Decile3, Decile4,

Table 8: Regression Results for VNET on the NYSE and Nasdaq using 2% Price Threshold

The following regression model is estimated in which the dependent variable is VNET, and the independent variables are the lagged time-weighted average bid-ask spread, the lagged natural logarithm of trade volume, the lagged natural logarithm of the number of trades, the natural logarithm of the forecast of eptime, the error from the forecast of eptime, and a binary variable set to one if the company is NYSE listed. The results are reported in Panel A. The regression model is:

$$VNET_{it} = \alpha + \beta_1 TWASpread_{it-1} + \beta_2 Vol_{it-1} + \beta_3 Trades_{it-1} + \beta_4 Eptime_{it} + \beta_5 Ptime\_err_{it} + \beta_6 NYSE_i + \varepsilon_{it} \qquad (1)$$

The results in Panel B are from equation (2), where binary variables have been added for the time period from which the observation originated and interaction terms between the time period binaries and NYSE listing binary. Binary variables for the decile rankings of the number of shares traded are also included. Deciles are ranked from lowest (0) to highest (9) volumes. P-values are reported in parentheses.

$$VNET_{it} = \alpha + \beta_1 TWASpread_{it-1} + \beta_2 Trades_{it-1} + \beta_3 EPtime_{it} + \beta_4 Ptime\_err_{it} + \beta_5 NYSE_i + \beta_6 Pre2001_i + \beta_7 Post2001_i + \beta_8 Post2002_i + \beta_9 Pre2001NYSE_i + \beta_{10} Post2001NYSE_i + \beta_{11} Post2002NYSE_i + \beta_{12} Decile1_i + \beta_{13} Decile2_i + \beta_{14} Decile3_i + \beta_{15} Decile4_i + \beta_{16} Decile5_i + \beta_{17} Decile6_i + \beta_{18} Decile7_i + \beta_{19} Decile8_i + \beta_{20} Decile9_i + \varepsilon_{it} \qquad (2)$$

Panel A: VNET on the NYSE and Nasdaq (N=16669)

Intercept	TWASpread	Vol	Trades	Eptime	Ptime_err	NYSE	Adj. R^2
4.47239	0.00217	0.34302	0.12156	0.25178	0.25597	0.40856	0.3111
(0.0001)	(0.2341)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	

Panel B: VNET on the NYSE and Nasdaq with Volume Deciles (N=16669)

Intercept	TWASpread	Trades	Eptime	Ptime_err	NYSE	Pre2001	Post2001	Post2002
5.7387	0.0021	0.3336	0.3105	0.2915	1.5101	0.1369	0.0866	0.4668
(0.0001)	(0.2436)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.1846)	(0.4242)	(0.0001)
Pre2001NYSE	Post2001NYSE	Post2002NYSE	Decile1	Decile2	Decile3	Decile4	Decile5	Decile6
-0.3478	-0.4948	-0.9562	-0.8265	-0.3486	-0.5782	-0.2149	-0.5509	0.0926
(0.0252)	(0.0024)	(0.0001)	(0.0001)	(0.0061)	(0.0001)	(0.0459)	(0.0001)	(0.3776)
Decile7	Decile8	Decile9						Adj. R^2
0.3125	0.6011	1.4588						0.3245
(0.0023)	(0.0001)	(0.0001)						

and Decile5 turn negative. However, the post-decimalization 2001 and 2002 NYSE interaction variables become statistically significant. Consequently, depth is a dynamic process with factor importance changing as the definition of an informational event, i.e. the return threshold, changes. Therefore, varying the return threshold specification results in the measurement of different types of information. Here, the 1% threshold for the NYSE sample in 1999 computes 2769 events or about 28 events per company each day. However, the 2% threshold over the same period estimates 691 events or 7 events per company every day.

These contradictions and changes in significance levels lead me to conclude that the 1% threshold is identifying noise trading as informational trading. It does not seem reasonable for there to be an average of 28 informational events per day for a company. As a result, the 2% and 1% thresholds are capturing different types or quantities of information.

Table 9 presents regression results for VNET on the Nasdaq, including Alternative Trading System effects, using the 1% threshold. Panel B includes the explanatory variables given in panel A and adds binary variables for 9 of the 10 deciles to capture differences in volume across deciles. Panel A estimates show that time-weighted average spreads are negatively related to depth. Trade volume, the number of trades, the conditional forecast of the time between price changes, and the error in the conditional forecast of time between price changes are positively related to VNET. The variables for the proportion of quotes posted on Nasdaq through ECNs and the proportion of trades executed through SOES are positively related to Nasdaq at the 0.05 level of significance.

Table 9: Regression Results for VNET on Nasdaq with ATS using 1% Price Threshold

The following regression model is estimated in which the dependent variable is VNET, and the independent variables are the lagged time-weighted average bid-ask spread, the lagged natural logarithm of trade volume, the lagged natural logarithm of the number of trades, the natural logarithm of the forecast of eptime, the error from the forecast of eptime, the proportion of quotes submitted to Nasdaq by ECNs, the proportion of trades executed with SelectNet, and the proportion of trades executed with the Small Order Execution System (SOES). The results are reported in Panel A. The regression model is:

$$VNET_{it} = \alpha + \beta_1 TWASpread_{it-1} + \beta_2 Vol_{it-1} + \beta_3 Trades_{it-1} + \beta_4 Eptime_{it} + \beta_5 Ptime\_err_{it} + \beta_6 ECN_{it} + \beta_7 SelectNet_{it} + \beta_8 SOES_{it} + \varepsilon_{it} \quad (1)$$

The results in Panel B are from equation (2), where binary variables have been added for decile rankings of the number of shares traded. Deciles are ranked from lowest (0) to highest (9) volumes.
P-values are reported in parentheses.

$$VNET_{it} = \alpha + \beta_1 TWASpread_{it-1} + \beta_2 Trades_{it-1} + \beta_3 EPtime_{it} + \beta_4 Ptime\_err_{it} + \beta_5 ECN_{it} + \beta_6 SelectNet_{it} + \beta_7 SOES_{it} + \beta_8 Decile1_i + \beta_9 Decile2_i + \beta_{10} Decile3_i + \beta_{11} Decile4_i + \beta_{12} Decile5i + \beta_{13} Decile6i + \beta_{14} Decile7_i + \beta_{15} Decile8_i + \beta_{16} Decile9_i + \varepsilon_{it} \quad (2)$$

Panel A: VNET on Nasdaq (N=4518)

Intercept	TWASpread	Vol	Trades	Eptime	Ptime_err	ECN	SelectNet	SOES
5.04311	-1.0712	0.14738	0.3863	0.32473	0.24993	0.19113	0.00441	2.39691
(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0367)	(0.9770)	(0.0001)
								Adj. R^2
								0.3441

Panel B: VNET on Nasdaq with Volume Deciles (N=4518)

Intercept	TWASpread	Trades	Eptime	Ptime_err	ECN	SelectNet	SOES	Decile1
5.69766	-0.94997	0.26503	0.30849	0.24733	0.22154	-0.17306	0.88355	0.09212
(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0134)	(0.2446)	(0.0910)	(0.5425)
Decile2	**Decile3**	**Decile4**	**Decile5**	**Decile6**	**Decile7**	**Decile8**	**Decile9**	**Adj. R^2**
0.40513	0.59606	0.49699	0.27287	0.45762	1.09456	1.39209	1.99532	0.3909
(0.0154)	(0.0001)	(0.0007)	(0.0507)	(0.0013)	(0.0001)	(0.0001)	(0.0001)	

When binary variables for volume deciles are included in panel B, the coefficient for SelectNet becomes negative, but remains insignificant. The variable SOES becomes insignificant at the 0.05 level. The volume decile binaries demonstrate a general increase in depth as volume ranking increases.

Table 10 provides regression results for VNET on Nasdaq, including Alternative Trading System effects, using the 2% threshold. The variables are the same as those given in Table 9 and are provided for a robustness check. VNET estimates using the 2% threshold instead of the 1% threshold to compute the dependent and independent variables are shown in panel A. The estimates present the coefficients to remain relatively stable. In panel B, the coefficient for SOES becomes significant at the 0.01 level, but the coefficient for ECNs becomes insignificant. Additionally, the sign for the SelectNet coefficient turns positive, but remains insignificant. Again, the return threshold specification can affect modeling of VNET.

3C. Conclusions

Unconditional t-tests show that VNET decreased on the NYSE from pre-decimalization 2001 to post-decimalization 2001. This is consistent with the findings that smaller tick sizes reduce liquidity; Harris (1997), Atkinson and Martin (1999), Smith (1998), Christie *et al*. (1999), and Bacidore, Battalio, and Jennings (2001). Decimalization however, caused no immediate impact on depth on the Nasdaq.

The impacts of decimalization on depth over the year following decimalization are strikingly different for the Nasdaq compared to the NYSE; VNET increased on the Nasdaq, but decreased on the NYSE. While the unconditional tests suggest depth

Table 10: Regression Results for VNET on Nasdaq with ATS using 2% Price Threshold

The following regression model is estimated in which the dependent variable is VNET, and the independent variables are the lagged time-weighted average bid-ask spread, the lagged natural logarithm of trade volume, the lagged natural logarithm of the number of trades, the natural logarithm of the forecast of eptime, the error from the forecast of eptime, the proportion of quotes submitted to Nasdaq by ECNs, the proportion of trades executed with SelectNet, and the proportion of trades executed with the Small Order Execution System (SOES).
The results are reported in Panel A. The regression model is:

$$VNET_{it} = \alpha + \beta_1 TWASpread_{it-1} + \beta_2 Vol_{it-1} + \beta_3 Trades_{it-1} + \beta_4 Eptime_{it} + \beta_5 Ptime\_err_{it} + \beta_6 ECN_{it} + \beta_7 SelectNet_{it} + \beta_8 SOES_{it} + \varepsilon_{it} \quad (1)$$

The results in Panel B are from equation (2), where binary variables have been added for decile rankings of the number of shares traded. Deciles are ranked from lowest (0) to highest (9) volumes. P-values are reported in parentheses.

$$VNET_{it} = \alpha + \beta_1 TWASpread_{it-1} + \beta_2 Trades_{it-1} + \beta_3 EPtime_{it} + \beta_4 Ptime\_err_{it} + \beta_5 ECN_{it} + \beta_6 SelectNet_{it} + \beta_7 SOES_{it} + \beta_8 Decile1_i + \beta_9 Decile2_i + \beta_{10} Decile3_i + \beta_{11} Decile4_i + \beta_{12} Decile5i + \beta_{13} Decile6i + \beta_{14} Decile7_i + \beta_{15} Decile8_i + \beta_{16} Decile9_i + \varepsilon_{it} \quad (2)$$

Panel A: VNET on Nasdaq (1763)

Intercept	TWASpread	Vol	Trades	Eptime	Ptime_err	ECN	SelectNet	SOES
4.7745	-1.06335	0.15621	0.41278	0.26468	0.23985	0.27208	0.36622	1.59493
(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0450)	(0.1333)	(0.0006)
								Adj. R^2
								0.3260

Panel B: VNET on Nasdaq with Volume Deciles (1763)

Intercept	TWASpread	Trades	Eptime	Ptime_err	ECN	SelectNet	SOES	Decile1
5.49431	-0.79216	0.33075	0.25907	0.24061	0.16866	0.07227	1.30697	-0.16572
(0.0001)	(0.0008)	(0.0001)	(0.0001)	(0.0001)	(0.2143)	(0.7653)	(0.0046)	(0.4417)
Decile2	Decile3	Decile4	Decile5	Decile6	Decile7	Decile8	Decile9	Adj. R^2
0.56654	0.70178	0.50978	0.41793	0.66579	0.82018	1.45847	1.70902	0.3561
(0.0123)	(0.0010)	(0.0155)	(0.0349)	(0.0011)	(0.0001)	(0.0001)	(0.0001)	

on the Nasdaq turns significantly greater than depth on the NYSE in the post-decimalization period, the regression analysis shows that after controlling the other factors in the model, NYSE listing is still associated with increased depth. The increase in depth on the Nasdaq supports Hypothesis 1, suggesting that bid curves and ask curves simultaneously pivoted, or flattened, upon the introduction of trading in decimals. The drop in depth on the NYSE is consistent with Hypothesis 2, suggesting that either investors changed their quotation behavior such that there was movement along the bid and ask curves, or there was a simultaneous pivot and shift in bid and ask curves.

Multivariate analysis shows that there was an insignificant increase in depth on the Nasdaq upon the implementation of trading in decimals. However, NYSE listed companies experienced an insignificant decrease in depth following the move to decimalization. Structural differences between the NYSE and Nasdaq, such as the aggregate use of limit orders, may explain the observed differences in depth.

Consistent with the findings of Chordia, Roll, and Subrahmanyam (2001), generally, depth increases in volume.

The impact of Alternative Trading Systems on depth for the Nasdaq has been significant. In general, higher proportions of quote activity through ECNs are associated with increased depth, supporting Hypothesis 3; the benefit of posting customer limit orders outweighs the possible increase in adverse selection costs arising from trader anonymity. Higher proportions of trading through SOES are associated with increased depth, supporting Hypothesis 7; small trades minimize traders' ability to use perishable information.

Comparative analysis of the effect of the selection of the threshold value suggests that different thresholds capture different information. For example, regression results for VNET on the NYSE and Nasdaq using the 1% return threshold suggest a significant negative relationship between depth and time-weighted average bid-ask spreads. However, regression results for VNET on the NYSE and Nasdaq using the 2% return threshold suggest an insignificant positive relationship between depth and time-weighted average bid-ask spreads. Consequently, researchers should be careful in specifying the threshold price or return used to identify informational events.

Chapter 4 Informed Trading

4A. Introduction

The amount of informed trading in financial markets can significantly affect both their ongoing development, and cost of capital for listing firms. For example, managerial trading in company stock prior to informational events has resulted in significant stock price decreases for some violating firms.[48] If the degree of informed trading is significantly different for alternative types of trading systems, then the growth of specific types of trading systems can have significant impacts on the overall amount of informed trading in those respective markets. Consequently, it is important for policy makers to understand that their implicit support of specific types of trading systems can affect the overall cost of capital for an economy. Ultimately, policy makers will need to known how informed trading differs across trading systems. It is the goal of this work to show how adverse selection costs from informed trading differ across Alternative Trading Systems.

Literature Review

Markets differ in a variety of ways. One difference, which can affect market quality, is the extent to which market participants can trade anonymously. Using data from the German stock market where non-anonymous traditional floor based exchanges co-exist with an anonymous computerized trading system, Grammig et al. (2001) show that the probability of informed trading is significantly lower in the floor based trading system. Economides and Schwartz (1995) and Schwartz and Steil (1996) note that

[48] A highly publicized case is that of ImClone Corporation. In 2001, three days before an announcement by the Food and Drug Administration of refusal to accept clinical trials submitted in support of a key drug approval application, several family members and friends of the CEO Waksal sold stock holdings in ImClone. When this information was disseminated to the market, ImClone's stock dropped precipitously.

institutional traders say they prefer an anonymous trading environment because they do not want to disclose their trading needs. Benveniste et al. (1992) suggest that anonymity allows informed traders to stay unidentified and consequently aggravate the adverse selection problem. Specifically, they show that brokers are motivated to share information with specialists about the trading motives of their customers because of the potential of specialists to price discriminate as retribution for having been exploited by broker informational advantages. Seppi (1990) models the coexistence of a non-anonymous upstairs market for block transactions and an anonymous trading floor. He shows informed market participants will not trade in the upstairs market because behavioral constraints they do not want to comply with can be enforced in the non-anonymous setting. Rhodes-Kropf (1998) investigates the coexistence of an anonymous and a non-anonymous dealer market. Since traders' identities are known in the non-anonymous market, dealers will negotiate prices inside the quoted spread. However, dealers will not negotiate in anonymous markets.

Prior research supports the idea that anonymity is related to higher adverse selection costs. De Jong *et al*. (1996) find that non-anonymously negotiated trades executed on the Paris Bourse's CAC systems have lower price impacts than regular CAC trades. Madhavan and Cheng (1997) show that traders who can credibly signal that liquidity needs motivate their trades, use the upstairs market. Garfinkel and Nimalendram (1998) show that Nasdaq stocks exhibit smaller increases in the bid-ask spread on insider-trading days than NYSE stocks. Consequently, they conclude that the Nasdaq is more conducive to anonymous trading than the NYSE. Heidle and Huang (2002) find the probability of informed trading to be lower on the NYSE for a sample of firms that switched listing from the Nasdaq to the NYSE.

Grammig *et al.* (2001) note that markets often differ with respect to the degree of anonymity they offer. Specifically, they state that most electronic crossing networks are completely anonymous whereas the New York Stock Exchange is not. However, trading on the NYSE is more anonymous than trading in the upstairs market for block trades. Similarly, under certain conditions, quotations placed through Electronic Communication Networks (ECNs) may be anonymous while dealer quotations on Nasdaq are not anonymous.[49]

Data

The data for this study were retrieved from the Nastraq and TAQ databases. Nastraq and TAQ are publicly available trade and quote data offered by Nasdaq and the New York Stock Exchange, respectively. All trades, quotes, trade times, quote times, trade sizes, quote sizes, and market maker identifiers for each quote are obtained from Nastraq for a sample of 100 Nasdaq listed companies. All trades, quotes, trade times, quote times, trade sizes, and quote sizes are obtained from TAQ for a sample of 100 NYSE listed companies.

To investigate differences in the probability of informed trading between the NYSE and Nasdaq, two matched portfolios are created. Firms are matched on the number of shares traded. First, all NYSE listed firms are ranked by the number of shares traded during December 1998 and placed into share volume deciles. The ten firms with the

[49] That is, the identity of the market maker quoting directly on Nasdaq is revealed.

highest volume from each decile are chosen, for a total of 100 firms. Next, all Nasdaq listed companies are sorted by number of shares traded during December 1998. Documented differences in trade reporting procedures between the NYSE and Nasdaq require Nasdaq trade volume to be adjusted to be comparable to NYSE trade volume.[50] Therefore, the number of shares traded for Nasdaq companies is divided by 2. Lastly, the closest Nasdaq adjusted volume is identified for each NYSE company. Any duplicate matches are eliminated by keeping the closest match and re-matching the duplicate (i.e. The Nasdaq companies are sampled without replacement.)

The high computational costs of trade and quote data cause researchers to limit both the number of companies and length of the period under investigation when investigating microstructure issues. For example, Engle and Lange (2001) use a sample of 17 NYSE listed, actively traded companies over 61 trading days to investigate market liquidity. Similarly, the sample employed here is limited to keep computational costs manageable.

For both the NYSE and Nasdaq portfolios, data are obtained covering four two-week periods; a two-week trading period one-year prior to the move to trading in decimals, the two-week period immediately preceding the move to trading in decimals, the two-week period immediately following decimalization, and a two-week period occurring one year after the beginning of trading in decimals.

The portfolio of Nasdaq companies is created from those companies that were subject to trading in decimals on April 19, 2001. Consequently, the period before decimalization ranges from Thursday, April 5, 2001 through Wednesday, April 18, 2001.

[50] See Daves, Wansley, and Zhang (2003) and Dyl and Anderson (2003).

The related one-year prior period is from April 19, 1999 to April 30, 1999. The immediate post period is from April 19, 2001 to May 2, 2001. The one-year anniversary post period extends from Friday, April 19, 2002 to Thursday, May 2, 2002.

The second portfolio includes only NYSE listed companies that were subject to trading in decimals on January 29, 2001. The companies in this portfolio are also selected by the ranking procedure detailed for Nasdaq listed companies. Therefore, the NYSE portfolio also includes 100 companies.

The portfolio of NYSE companies is a subset of those companies that were subject to trading in decimals on January 15, 2001. Consequently, the one-year prior period is from January 29, 1999 to February 11, 1999. The sample period before decimalization ranges from Monday, January 15, 2001 through Friday, January 26, 2001. The immediate post period is from January 29, 2001 to February 9, 2001. The one-year anniversary post period extends from Tuesday, January 29, 2002 to Monday, February 11, 2002.

4B. Methodology

Easley, Kiefer, O'Hara, and Paperman (1996) specify a model to estimate the risk of information-based trading on a single market.[51] During a period T, a trading day, a risky asset is traded in a dealer market and an alternative trading system. In both markets, a risk neutral competitive dealer quotes bid and ask prices for one unit of a risky asset.

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[51] Grammig *et al.* (2001) develop and estimate a structural model that builds on Easley *et al.* (1996) and Easley and O'Hara (1987, 1992). The extension by Grammig et al. accounts for parallel trading in two markets, which is the market framework for securities that simultaneously trade on a listing market or exchange and an ECN. However, since the data used in this study do not identify ECN trades, the Grammig *et al.* model cannot be employed.

Trading results from market buy and sell orders submitted by a large number of traders. Some of these trades are potentially informed trades.

Time is indexed by $t \in [0,T]$. Trading days are indexed by $i \in [1,I]$. Nature determines whether an informational event occurs prior to the start of the trading day. Informational occurrences are assumed to be independent across trading days and occur with probability α. In the absence of an informational event, the asset value is V_i^*. When an informational event occurs, the asset value is $\underline{V_i} < V_i^*$ with probability δ and $\overline{V}_i > V_i^*$ with probability 1-δ. That is, δ is the probability of a bad or negative informational event and (1- δ) is the probability of a good or positive informational event. The asset value is revealed at the close of the trading day. Informational events are assumed to be independent across trading days.

Two groups of traders exist; informed traders and uninformed traders. Uninformed traders trade for liquidity purposes without knowing the underlying asset's value or if an informational event has taken place. However, informed traders know the true asset value and when informational events occur. Consequently, informed traders only trade when informational events take place.

The order arrival processes are modeled as independent Poisson processes. The arrival rate of uninformed buy and sell orders is denoted by ε. The arrival rate of informed traders on days with information events is μ. The arrival rate of informed traders is zero on days without informational events.

Traders know the unconditional probabilities of an informational event, and they know the order arrival rates, but they do not observe whether an informational event occurred. Traders use Bayes' rule to update their beliefs during the trading day. All order arrival rates are assumed to be independent.

At the beginning of the trading day, i.e. time zero, a market participant's beliefs about the probabilities for no news, bad news, and good news informational events are equivalent to unconditional probabilities. Formally, "no news" (n), "bad news" (b), and "good news" (g) correspond to $P(0) = (1-\alpha, \alpha\delta, \alpha(1-\delta))$. Using Bayes' rule, these probabilities are updated after each trade; the vector of subjective probabilities conditional on the trade history in the market prior to time t are denoted by $P(\mathrm{t}) = (P_{\mathrm{n}}(\mathrm{t}), P_{\mathrm{b}}(\mathrm{t}), P_{\mathrm{g}}(\mathrm{t}))$. Therefore, the expected asset value conditioned on the trade history, is

$$E\ (V_i \mid t) = P_n(t)V_i^* + P_b(t)\underline{V}_i + P_g(t)\overline{V}_i. \qquad (1)$$

The market maker establishes bid prices $b(t)$ and ask prices $a(t)$ equal to the conditional expectation of the asset value, given that the next trade is a seller-initiated and buyer-initiated, respectively. The resulting bid-ask spread is

$$\begin{aligned} s(t) &= a(t) - b(t) \\ &= PI_{Buy}(t)(\overline{V}_i - E[V_i \mid t]) + PI_{Sell}(t)(E[V_i \mid t] - \overline{V}_i), \quad (2) \end{aligned}$$

where $PI_{\mathrm{Buy}}(t)$ and $PI_{\mathrm{Sell}}(t)$ are the conditional probabilities that the next buyer-initiated and seller-initiated trades are motivated by information. Consequently, the spread at time t equals the probability that a buy is information-based multiplied by the expected loss to an informed buyer, including an asymmetric term for sells. The probability that any trade that occurs at time t is information-based is the average of the probability of an information-based sell and the probability of an information based buy, weighted by the probability that the next transaction is buyer-initiated or seller-initiated. Formally,

$$PI(t) = \text{Prob}(buy)PI_{Buy}(t) + \text{Prob}(sell)PI_{Sell}(t)$$

$$= \frac{\mu(P_g(t) + P_b(t))}{2\varepsilon + \mu(P_g(t) + P_b(t))} \tag{3}$$

The probability of an informed trade at the opening is based on the unconditional probabilities,

$$PI \equiv PI(0) = \frac{\alpha\mu}{\alpha\mu + 2\varepsilon}. \tag{4}$$

Easley *et al.* (1996) estimate the parameters; α, δ, ε, and μ for a single market. The unconditional probability of encountering an informed trader $PI(0)$ can be determined using these parameters.[52]

The resulting likelihood of observing S_i sells and B_i buys by a market maker on a day no news day i is

$$I_{n,i} = \exp[-2(\varepsilon T)\frac{(\varepsilon T)^{B_i}(\varepsilon T)^{S_i}}{B_i!S_i!}] \tag{6}$$

Equation (6) is the product of the densities of two independent Poisson processes that determine the rival of uninformed buyers and sellers in the two trading systems. Respectively, the likelihoods for a "bad news day" and a "good news day" are

$$I_{b,i} = \exp(-(2\varepsilon + \mu)T)\ \frac{(\varepsilon T)^{B_i}[(\varepsilon + \mu)T]^{S_i}}{B_i!S_i!} \tag{7}$$

$$I_{g,i} = \exp(-(2\varepsilon + \mu)T)\ \frac{(\varepsilon T)^{S_i}[(\varepsilon + \mu)T]^{B_i}}{B_i!S_i!} \tag{8}$$

[52] Grammig *et al.* (2001) extend this model to estimate the parameters for two markets and test the hypothesis that the probability of encountering an informed trader in an anonymous screen-based trading system is higher than the corresponding probability on an exchange floor.

The likelihood of observing $\Omega_i = \{S_i, B_i\}$ on a day which the occurrence of an informational event is not known is the weighted average of equations (6)-(8):

$$l_i = (1-\alpha)I_{n,i} + \alpha\delta I_{b,i} + \alpha(1-\delta)I_{g,i}. \tag{9}$$

Since news events are assumed to be independent across days, the likelihood of observing the data $M = \{\Omega_i\}_{i=1}^{I}$ over a I days is

$$L(M \mid \theta) = \prod_{i=1}^{I} l_i . \tag{10}$$

Equation 10 is maximized with respect to the parameter vector θ to obtain maximum likelihood estimates of the parameters. The probabilities α and δ range are bound between 0 and 1. Approximate standard errors are estimated from the covariance matrix.

To investigate the impact of Alternative Trading Systems on the probability of informed trading (PIN), the following time-series cross sectional equation is estimated

$$\begin{aligned} PIN_i \quad &= \alpha + \beta_1 LOG(Trades) + \beta_3 ECN_i + B_4 SelectNet_i + \\ &\beta_5 SOES_i + \varepsilon_i \end{aligned} \tag{11}$$

where *trades* is the average number of trades, *ECN* is the proportion of all quotes posted to Nasdaq that were submitted by ECNs, *SelectNet* is the proportion of all trades executed through SelectNet, and *SOES* is the proportion of all trades executed through SOES.

In the framework of Admati and Pfleiderer (1988), informed traders prefer to trade during periods when they are less likely to be discovered. Consequently, informed traders desire to trade when trading activity is high. Therefore, a negative relationship is expected between the probability of informed trading and the average number of transactions for a given company.

Orders executed through ECNs can be submitted anonymously. As a result, the likelihood of encountering an informed trader should increase as the proportion of quotes submitted by ECNs increase.

SOES executed trades are also anonymous. However, SOES orders are small individual investor orders. Since SOES order sizes are limited to small numbers of shares, the ability of informed traders to take advantage of perishable information is minimized. Consequently, higher proportions of SOES trading should decrease the probability of informed trading.

Lastly, SelectNet allows participants to electronically negotiate trade terms. The identities of the counterparties to the trade are revealed during the negotiation process. If a trader is concerned about her reputation and future ability to obtain favorable trade terms, then she is less likely to attempt to take advantage of informational advantages when her identity is known. Thus, increased trading through SelectNet should decrease the probability of informed trading.

Hypotheses for the Effects of Alternative Trading Systems of the Probability of Informed Trading

Hypothesis 1:

The benefits of posting customer limit orders through ECNs outweighs the costs of trader anonymity. In the Admati and Pfleiderer (1988) framework where liquidity *traders and informed traders prefer to trade during active periods, informed traders are less likely to be recognized because of the high number of active traders. Consequently, companies with more ECN trade and quote activity should have lower probabilities of informed trading.*

Hypothesis 2:

The higher adverse selection costs arising from trader anonymity dominate all possible benefits arising from ECN participation. Consequently, companies with more ECN trade and quote activity should have higher probabilities of informed trading.

Hypothesis 3:

SelectNet users can reveal their identities, thereby reducing adverse selection costs. As a result, higher proportions of non-anonymous SelectNet trades should result in lower probabilities of informed trading.

Hypothesis 4:

SOES trades are small anonymous trades. Mandated small order sizes minimize traders' ability to use perishable information. Therefore, higher proportions of SOES trading should lower the probability of informed trading.

Assuming that the benefits of the posting of limit orders to ECNs is dominated by the negative effects of greater trader anonymity, then as the proportion of the total number of trades executed through an ECN increases for a given company, market depth should decrease.[53]

SelectNet allows market participants to reveal their identity when electronically negotiating the terms of a trade. When an investor chooses to reveal his identity, it is less likely that he is attempting to exploit the counterparty by taking advantage of private information. Consequently, counterparties should be more willing to negotiate favorable trade terms through SelectNet. As a result, SelectNet should increase market depth.

The effects of Nasdaq's Small Order Execution System are less clear. Orders executed through SOES tend to be small, individual investor orders. However, the orders are anonymous. If information asymmetry costs dominate the benefits of reduced order execution times, the SOES orders reduce market depth.

[53] Neither Nastraq nor TAQ data identify the party responsible for a given trade. Consequently, the proportion of the total number of trades executed through an ECN is proxied by the proportional of all quotations submitted through an ECN.

Chapter 5 Informed Trading Results

5A. Unconditional Results

Table 11 presents the average probability of informed trading by decile for both the NYSE and Nasdaq. In general, lower volume stocks have higher probabilities of informed trading. The average probability of informed trading for the NYSE sample decreases from 14.42% in 1999 to 12.67% in 2002. While the average probability of informed trading on the Nasdaq is more variable from one period to the next, it appears stable over the long-term with estimates of 21.32% in 1999 and 21.17% in 2002. Overall, the probability of informed trading appears higher for the matched sample of Nasdaq firms than for the NYSE firms. These differences are tested further in later tables.

Next, the effects of Alternative Trading Systems on the probability of informed trading are investigated for the Nasdaq. Table 12 lists the recognized Electronic Communication Networks that are included in this study. For the 1999 to 2002 period, there are 10 qualified ECNs.

Table 13 offers summary statistics for quote activity of ECNs and trade activity of SOES and SelectNet. The mean values of the proportion of all quotes posted through Nasdaq by ECNs are presented for share volume ranked deciles. Mean values for SOES and SelectNet are the proportions of trades executed through the respective trading systems. From 1999 to 2001, the highest volume deciles have the highest proportions of ECN quotation activity. In 2002, the highest volume deciles actually have the lowest proportions of ECN quote activity. However, the highest volume deciles do have the greatest number of quotations by ECNs.

Table 11: The Probability of Informed Trading

The Probability of Informed Trading is computed across four two-week trading periods for matched samples of NYSE and Nasdaq listed companies. Firms are placed into deciles by ranking total monthly share trading volume in December 1998.

	Low Volume				Decile				High Volume		
1999	0	1	2	3	4	5	6	7	8	9	Average
NYSE (N=1000)	27.00%	14.24%	17.77%	13.93%	12.98%	13.69%	13.15%	9.05%	10.14%	12.28%	14.42%
Nasdaq (N=1000)	33.86%	21.63%	29.82%	29.66%	18.62%	16.36%	18.36%	15.63%	16.37%	12.88%	21.32%

					Decile						
2001 Pre-Decimalization	0	1	2	3	4	5	6	7	8	9	Average
NYSE (N=1000)	19.64%	16.92%	19.19%	14.73%	12.65%	12.54%	14.55%	13.93%	12.56%	9.03%	14.57%
Nasdaq (N=1000)	23.88%	20.72%	20.40%	19.83%	13.11%	15.83%	17.44%	19.25%	15.17%	24.67%	19.03%

					Decile						
2001 Post-Decimalization	0	1	2	3	4	5	6	7	8	9	Average
NYSE (N=1000)	23.04%	16.31%	16.60%	16.82%	12.09%	12.81%	13.10%	9.22%	12.08%	11.69%	14.38%
Nasdaq (N=1000)	36.37%	28.17%	20.63%	24.59%	18.60%	20.67%	16.94%	20.36%	22.99%	32.90%	24.22%

					Decile						
2002	0	1	2	3	4	5	6	7	8	9	Average
NYSE (N=1000)	16.51%	17.78%	12.37%	12.12%	14.79%	12.14%	11.31%	8.23%	13.12%	8.27%	12.67%
Nasdaq (N=1000)	23.34%	20.79%	24.19%	30.68%	24.01%	11.61%	18.15%	22.02%	15.64%	21.29%	21.17%

Table 12: Electronic Communication Networks (ECNs)

The following trading systems are considered linked-ECNs and are appropriately identified in the study.	
Archipelago ECN	ARCA
Attain ECN	ATTN
Brass Utility ECN	BRUT
Bloomberg Trade Book ECN	BTRD
Instinet ECN	INCA
Island ECN	ISLD
Nextrade ECN	NTRD
Spear Leeds & Kellogg ECN	REDI
Strike Technologies ECN	STRK
Market XT ECN	MKXT

Table 13: Alternative Trading System Statistics

Summary statistics are presented for quote activity of Electronic Communication Networks (ECNs) and trade activity of the Small Order Execution System (SOES) and SelectNet. The mean values of the proportion of all quotes posted through Nasdaq by ECNs are presented for share volume ranked deciles of 100 Nasdaq listed companies. Firms are placed into deciles by ranking December 1998 total monthly share trading volume from lowest to highest. Mean values for SOES and SelectNet are the proportion of all trades executed by the respective systems.

Panel A: ECNs

	Lowest Volume				Decile				Highest Volume	
1999	0	1	2	3	4	5	6	7	8	9
Mean	25%	24%	27%	23%	24%	32%	34%	35%	38%	58%
Frequency	2791	4314	8274	8678	14529	33267	29706	97861	207224	1533796
Standard Deviation	0.4321	0.4299	0.4432	0.4220	0.4244	0.4673	0.4742	0.4779	0.4852	0.4933
2001 Pre-Decimalization										
Mean	57%	67%	75%	75%	67%	67%	73%	70%	74%	70%
Frequency	6043	17585	55884	308988	81775	230516	102726	605364	1050917	4781472
Standard Deviation	0.4957	0.4718	0.4305	0.4322	0.4704	0.4688	0.4462	0.4602	0.4411	0.4598
2001 Post-Decimalization										
Mean	60%	65%	75%	72%	64%	67%	68%	67%	70%	70%
Frequency	15962	22756	58083	348678	119112	242196	105386	734659	1254864	5240970
Standard Deviation	0.4893	0.4759	0.4312	0.4483	0.4802	0.4719	0.4650	0.4710	0.4571	0.4589
2002										
Mean	78%	75%	79%	81%	81%	79%	79%	77%	77%	70%
Frequency	77555	54550	92887	281293	104349	333057	164700	1117649	1394252	6168733
Standard Deviation	0.4118	0.4355	0.4079	0.3900	0.3957	0.4038	0.4040	0.4233	0.4188	0.4599

Table 13: Continued

Panel B: SOES										
	Lowest Volume				Decile				Highest Volume	
1999	0	1	2	3	4	5	6	7	8	9
Mean	4%	4%	2%	3%	4%	6%	3%	6%	8%	7%
Frequency	1855	3002	6004	6712	10709	21740	24291	68083	139605	1584127
Standard Deviation	0.1919	0.1904	0.1530	0.1650	0.1883	0.2381	0.1620	0.2367	0.2744	0.2517
2001 Pre-Decimalization										
Mean	2%	3%	2%	7%	5%	8%	2%	7%	6%	6%
Frequency	2575	6939	17786	139359	27357	89498	34655	342352	549722	4467907
Standard Deviation	0.1380	0.1628	0.1526	0.2498	0.2129	0.2782	0.1229	0.2553	0.2448	0.2461
2001 Post-Decimalization										
Mean	5%	2%	3%	7%	8%	7%	2%	7%	6%	6%
Frequency	5592	7505	15121	103678	35188	78340	28865	338056	539033	3844241
Standard Deviation	0.2174	0.1505	0.1593	0.2612	0.2703	0.2584	0.1216	0.2630	0.2407	0.2463
2002										
Mean	23%	26%	25%	20%	24%	23%	23%	23%	24%	23%
Frequency	20798	17640	20712	55733	30330	92723	45184	280386	374591	3519392
Standard Deviation	0.4239	0.4408	0.4306	0.4005	0.4296	0.4180	0.4214	0.4177	0.4245	0.4227

Table 13: Continued

Panel C: SelectNet										
	Lowest Volume				Decile					Highest Volume
1999	0	1	2	3	4	5	6	7	8	9
Mean	30%	28%	28%	33%	34%	36%	29%	27%	28%	19%
Frequency	1855	3002	6004	6712	10709	21740	24291	68083	139605	1584127
Standard Deviation	0.4604	0.4511	0.4484	0.4698	0.4736	0.4798	0.4532	0.4463	0.4475	0.3941
2001 Pre-Decimalization										
Mean	53%	52%	52%	28%	49%	50%	48%	34%	34%	23%
Frequency	2575	6939	17786	139359	27357	89498	34655	342352	549722	4467907
Standard Deviation	0.4992	0.4997	0.4994	0.4469	0.4999	0.5000	0.4997	0.4721	0.4743	0.4212
2001 Post-Decimalization										
Mean	48%	50%	50%	29%	49%	51%	48%	32%	33%	24%
Frequency	5592	7505	15121	103678	35188	78340	28865	338056	539033	3844241
Standard Deviation	0.4997	0.5000	0.5000	0.4557	0.4999	0.4998	0.4998	0.4673	0.4698	0.4254
2002										
Mean	10%	12%	14%	11%	12%	15%	11%	9%	10%	6%
Frequency	20798	17640	20712	55733	30330	92723	45184	280386	374591	3519392
Standard Deviation	0.3048	0.3264	0.3499	0.3074	0.3276	0.3577	0.3150	0.2862	0.2936	0.2404

Summary statistics for SOES trading activity show that from 1999 through 2001, the proportion of trading through SOES if higher for higher volume securities. SOES trading activity jumps from 2001 to 2002 as a result of trading system changes to SOES and SelectNet.

In general, summary statistics for SelectNet show higher proportions of trading for lower volume stocks. SelectNet trading activity decreases from 2001 to 2002 as a result of trading system changes to SOES and SelectNet.

Table 14, panel A offers unconditional t-tests for time period differences in the mean proportions of all quotes submitted to Nasdaq through ECNs, and all trades executed through SOES and SelectNet. From 1999 to 2002, there are significant increases in ECN quote activity and SOES trading activity at the 0.01 level of significance. SelectNet shows a substantial decline in trading activity at the same level of significance. Mean quote and trade proportions do not change for any system as a result of decimalization during the two-week periods prior to and following the move to decimals. However, from pre-decimalization 2001 to 2002, there are significant decreases in ECN and SelectNet activity, but a significant increase in SOES activity.

Table 14, panel B presents unconditional t-tests for volume rank differences in the mean proportions of all quotes submitted to Nasdaq through ECNs and all trades executed by SOES and SelectNet. The proportions of quotes originating from ECNs and trades executed by SOES typically are higher for the high volume decile (9) than the low volume (0) decile. However, the proportion of trades executed by SelectNet drops as volume increases.

Table 14: Unconditional Alternative Trading Systems T-tests

Panel A

Unconditional t-tests are employed to test for differences in the mean proportions of all quotes or trades posted to Nasdaq and submitted through Electronic Communication Networks (ECNs), the Small Order Execution System (SOES), or SelectNet, respectively. Differences in mean proportions are tested by comparing 1999 values with 2002 values, Pre-Decimalization 2001 with Post-Decimalization values, and Pre-Decimalization 2001 with 2002 values.

	1999 Mean	2002 Mean	t-Value	p-Value
ECN	0.2445	0.7517	12.88	0.0001
SelectNet	0.2599	0.0920	-10.93	0.0001
SOES	0.0319	0.2222	23.05	0.0001

	Pre-2001 Mean	Post-2001 Mean	t-Value	p-Value
ECN	0.6535	0.6481	-0.65	0.5215
SelectNet	0.3412	0.3388	-0.19	0.8541
SOES	0.0305	0.0368	0.52	0.6126

	Pre-2001 Mean	2002 Mean	t-Value	p-Value
ECN	0.7517	0.6535	4.00	0.0008
SelectNet	0.3412	0.0920	-8.42	0.0001
SOES	0.0305	0.2222	19.64	0.0001

Table 14: Continued

Panel B

Differences in the mean proportions of all quotes and trades from Low Volume and High Volume share deciles are tested for ECNs, SOES, and SelectNet. Differences in means are computed separately for 1999, Pre-Decimalization 2001, Post-Decimalization 2001, and 2002.

	Low Volume (0)	High Volume (9)		
1999	Mean	Mean	t-Value	p-Value
ECN	0.2323	0.5810	-35.69	0.0001
SelectNet	0.2836	0.1916	12.27	0.0001
SOES	0.0295	0.0676	-5.08	0.0001

	Low Volume (0)	High Volume (9)		
Pre-2001	Mean	Mean	t-Value	p-Value
ECN	0.5531	0.6959	-22.08	0.0001
SelectNet	0.5108	0.2302	36.07	0.0001
SOES	0.0141	0.0645	-9.35	0.0001

	Low Volume (0)	High Volume (9)		
Post-2001	Mean	Mean	t-Value	p-Value
ECN	0.5952	0.6981	-26.29	0.0001
SelectNet	0.4678	0.2368	42.80	0.0001
SOES	0.0440	0.0646	-4.60	0.0001

	Low Volume (0)	High Volume (9)		
2002	Mean	Mean	t-Value	p-Value
ECN	0.7807	0.6959	52.64	0.0001
SelectNet	0.0995	0.0613	25.10	0.0001
SOES	0.2290	0.2325	0.64	0.5212

5B. Multivariate Results

Table 15 presents regression results for the probability of informed trading (PIN) on the NYSE and Nasdaq. Panel A shows an inverse relationship between the probability of informed trading and the number of trades for a given firm. The probability of informed trading is significant lower on the NYSE than on Nasdaq for the matched sample of firms.

Table 15, panel B includes the same explanatory variables as panel A, but adds binary variables to capture the effects of higher volume on the probability of informed trading. The effects of exchange listing and the number of trades do not change when the binaries are included. The estimates show that probability of informed trading varies by volume rank, but does not monotonically decrease as volume increases. In fact, volume deciles 1, 2, 4 and 5 have the lowest probabilities of informed trading.

Table 16 presents regression results for the probability of informed trading on the Nasdaq, including Alternative Trading System effects. Panel A shows that PIN decreases as the proportion of ECN quotations increases and the number of trades increases. However, the proportions of trading through SOES and SelectNet do not significantly affect the probability of informed trading. PIN is slightly higher in 2001 than the other periods.

Table 16, panel B includes includes the same explanatory variables as panel A, but adds binary variables to capture the effects of higher volume on the probability of informed trading. Generally, volume ranking does not impact the probability of informed

Table 15: Regression Results for the Probability of Informed Trading on the NYSE and Nasdaq

The following regression model is estimated in which the dependent variable is the probability of informed trading, and the independent variables are the natural logarithm of the number of trades and a binary variable set to one if the company is NYSE listed. The results are reported in Panel A. The regression model is:

$$PIN_i = \alpha + \beta_1 LnTrades_i + \beta_2 NYSE_i + \varepsilon_i \qquad (1)$$

The results in Panel B are from equation (2), where binary variables have been added for decile rankings of the number of shares traded. Deciles are ranked from lowest (0) to highest (9) volumes. P-values are reported in parentheses.

$$PIN_i = \alpha + \beta_1 LnTrades_i + \beta_2 NYSE_i + \beta_3 Decile1_i + \beta_4 Decile2_i + \beta_5 Decile3_i + \beta_6 Decile4_i + \beta_7 Decile5_i + \beta_8 Decile6_i + \beta_9 Decile7_i + \beta_{10} Decile8_i + \beta_{11} Decile9_i + \varepsilon_i \qquad (2)$$

Panel A: The Probability of Informed Trading on NYSE and Nasdaq

Intercept	LnTrades	NYSE	Adj. R^2
0.40465	-0.0263	-0.0799	0.3465
(0.0001)	(0.0001)	(0.0001)	

Panel B: The Probability of Informed Trading on NYSE and Nasdaq with Volume Deciles

Intercept	LnTrades	NYSE	Decile1	Decile2	Decile3	Decile4	Decile5	Decile6
0.4564	-0.0298	-0.0828	-0.0417	-0.0424	-0.0116	-0.0540	-0.0425	-0.0290
(0.0001)	(0.0001)	(0.0001)	(0.0020)	(0.0019)	(0.3984)	(0.0001)	(0.0036)	(0.0467)

Decile7	Decile8	Decile9	Adj. R^2
-0.0264	-0.0078	0.0104	0.3704
(0.0864)	(0.6311)	(0.5957)	

Table 16: Regression Results for the Probability of Informed Trading and the Alternative Trading System Effect

The following regression model is estimated in which the dependent variable is the probability of informed trading, and the independent variables are the proportion of quotes submitted to Nasdaq by Electronic Communication Networks, the proportion of trades executed with the Small Order Execution System, the proportion of trades executed with SelectNet, the natural logarithm of the number of trades, a binary variable set to one if the data are from the time period Jan. 21, 2001-Feb. 7, 2001, a binary variable set to one if the data are from the time period May. 14, 2001-May 28, 2001, and a binary variable set to one if the data are from the time period May. 14, 2002-May 28, 2002. The regression model is:

$$PIN_i = \alpha + \beta_1 ECN_i + \beta_2 SOES_i + \beta_3 SelectNet_i + \beta_4 LnTrades_i + \beta_5 Pre2001_i + \beta 6Post2001i + \beta 7Post2002i + \varepsilon i \quad (3)$$

The results in Panel B are from equation (4), where binary variables have been added for decile rankings of the number of shares traded. Deciles are ranked from lowest (0) to highest (9) volumes. P-values are reported in parentheses.

$$PIN_i = \alpha + \beta_1 ECN_i + \beta_2 SOES_i + \beta_3 SelectNet_i + \beta_4 LnTrades_i + \beta_5 Pre2001_i + \beta_6 Post2001_i + \beta_7 Post2002_i + \beta_8 Decile1_i + \beta_9 Decile2_i + \beta_{10} Decile3_i + \beta_{11} Decile4_i + \beta_{12} Decile5_i + \beta_{13} Decile6_i + \beta_{14} Decile7_i + \beta_{15} Decile8_i + \beta_{16} Decile9_i + \beta_{17} Decile10_i + \varepsilon_i \quad (4)$$

Panel A: The Probability of Informed Trading and the Alternative Trading System Effect

Intercept	ECN	SelectNet	SOES	LnTrades	Pre2001	Post2001	Post2002	Adj. R^2
0.4402	-0.1189	0.0046	0.0365	-0.0268	0.0339	0.0330	0.0398	0.4335
(0.0001)	(0.0002)	(0.9365)	(0.6342)	(0.0001)	(0.0448)	(0.0466)	(0.1337)	

Panel B: The Probability of Informed Trading and the Alternative Trading System Effect with Volume Decile

Intercept	ECN	SelectNet	SOES	LnTrades	Pre2001	Post2001	Post2002	Decile1
0.4424	-0.1092	0.0334	0.0475	-0.0251	0.0257	0.0251	0.0386	-0.02704
(0.0001)	(0.0007)	(0.5788)	(0.5379)	(0.0001)	(0.1360)	(0.1381)	(0.1432)	(0.1665)
Decile2	Decile3	Decile4	Decile5	Decile6	Decile7	Decile8	Decile9	Adj. R^2
-0.0387	0.0058	-0.0616	-0.0391	-0.0407	-0.0130	-0.0105	-0.0403	0.4499
(0.0530)	(0.7689)	(0.0026)	(0.0779)	(0.0493)	(0.5561)	(0.6597)	(0.1592)	

trading. Time effects become insignificant when volume rankings are included. ECNs remain negatively related to the probability of informed trading.

5C. Conclusions

Unconditional t-tests find the probability of informed trading to be lower for the NYSE sample firms than for the Nasdaq sample of firms. This result is supported by the finding of Heidle and Huang (2002) that the probability of informed trading is lower on the NYSE for a sample of firms switching listing from the Nasdaq to the NYSE. Furthermore, it is consistent with the conjecture of Garfinkel and Nimalendram (1998) that the Nasdaq is more anonymous than the NYSE.

Quotation activity through ECNs extends from primarily high volume stocks in 1999 to all stocks by 2002. SOES trading is slightly higher for high volume stocks, while SelectNet trading is higher for lower volume stocks. Quote and trade activity for ECNs, SOES, and SelectNet do not significantly change upon the move to decimal trading. Additionally, the probability of informed trading is shown to vary by volume decile ranking.

Similar to the unconditional evidence, multivariate regressions show the probability of informed trading is lower on the NYSE than on Nasdaq. Brockman and Chung (1999) suggest that limit order trading results in lower adverse selection costs. Consequently, the lower probability of informed trading on the NYSE may come from higher levels of limit order trading.

Estimates of the impact of the proportion of quotations placed through ECNs show that the probability of informed trading decreases as the proportion of ECN quotations increases. However, the proportion of trades executed through SOES and SelectNet do not significantly affect the probability of informed trading. Generally, volume ranking does not impact the probability of informed trading on Nasdaq. Thus, only Hypothesis 1 is supported.

Chapter 6 Simultaneous Equations

6A. Methodology

This chapter investigates the possibility that traders simultaneously establish and react to depth and spreads while also considering adverse selection costs. Easley *et al.* (1996) only consider the effects of volume and the probability of informed trading on spreads. Engle and Lange (2001) do not consider adverse selection costs in their specification of depth. However, when market participants quote a certain size and price for a security, they consider many factors. Important factors a trader might consider include; current spreads and the quoted volume associated with those spreads, current inventory levels and desired inventory levels, order flow, proprietary information, and adverse selection. Consequently, spreads, depth, and the probability of informed trading appear to be determined contemporaneously.

Green (2000) offers two stage least squares as a technique to model simultaneous equations when endogenous variables exist. Therefore, a two stage least squares model is employed to measure the simultaneous impact of Alternative Trading Systems on depth, the probability of informed trading, and time-weighted average spreads. The following two stage least squares model is estimated in equations 1-3

$$\begin{aligned} VNET\_Mean_i = \alpha + \beta_1 TWA\_Mean_i + \beta_2 Vol\_Mean_i + \beta_3 Trades\_Mean_i\ + \\ \beta_4 Eptime\_Mean_i + \beta_5 Ptime\_err\_Mean_i + \beta_6 ECN\_Mean_i\ + \\ \beta_7 SelectNet\_Mean_i + \beta_8 SOES\_Mean_i + \varepsilon_i \qquad (1) \end{aligned}$$

$$\begin{aligned} PIN_i = \alpha + \beta_1 Trades\_Mean_i + \beta_2 VNET\_Mean_i + \beta_3 ECN\_Mean_i\ + \\ B_4 SelectNet\_Mean_i + \beta_5 SOES\_Mean_i + \varepsilon_i \qquad (2) \end{aligned}$$

$$TWA\_Mean_i = \alpha + \beta_1(Price\_Mean \times PIN)_i + \beta_2 Trades\_Mean_i + \beta_6 ECN\_Mean_i + \beta_7 SelectNet\_Mean_i + \beta_8 SOES\_Mean_i + \varepsilon_i \quad (3)$$

where VNET_Mean is the average VNET computed separately for each two-week trading period, TWA_Mean is the average time-weighted average bid-ask spread, Vol_Mean is the average the average share volume, Trades_Mean the average number of trades, Eptime_Mean is the average conditional forecast of time between price durations, Ptime_err_Mean is the average error of the conditional forecast of time between price durations, ECN_Mean is the average proportion of quotes posted to Nasdaq originating from ECNs, SelectNet_Mean is the average proportion of trades executed through SelectNet, SOES_Mean is the average proportion of trades executed through SOES, PIN is the probability of informed trading, and Price_Mean is the average trade price.

6B. Two Stage Least Squares Results

Table 17 presents two-stage least squares regression results for the Nasdaq, including Alternative Trading System effects, using the 1% price threshold to compute VNET. Equation 1 estimates show depth decreases as time-weighted bid-ask spreads increase. However, depth increases in trading volume, the number of trades, and the conditional time between trades. Higher proportions of quotations placed through ECNs and proportions of trades executed through SOES are related to increased depth. Comparatively, higher proportions of trading through SelectNet are related to lower depth. Compared to the regression results presented in Table 9, the impacts of Alternative

Table 17: Two Stage Least Squares Regression Results on Nasdaq with ATS using 1% Price Threshold

The following two stage least squares regression model is estimated using three simultaneous equations. In equation (1), the dependent variable is the average VNET computed for each of the following two-week trading periods: Apr 19, 1999 - Apr 30, 1999, Apr 5, 2001 - Apr 18, 2001, Apr 19, 2001 - May 2, 2001, and Apr 19, 2002 - May 2, 2002. The independent variables are the time-weighted average bid-ask spread, the lagged natural logarithm of trade volume, the lagged natural logarithm of the number of trades, the natural logarithm of the forecast of eptime, the error from the forecast of eptime, the proportion of quotes submitted to Nasdaq by Electronic Communication Networks (ECNs), the proportion of trades executed with SelectNet, and the proportion of trades executed with the Small Order Execution System (SOES). The independent variables are averaged over the same time periods as VNET.

The probability of informed trading (PIN) is the independent variable in equation (2). PIN is estimated over the detailed two-week trading periods. The independent variables are the lagged natural logarithm of the number of trades, VNET, the proportion of quotes submitted to Nasdaq by ECNs, the proportion of trades executed with SelectNet, and the proportion of trades executed with the SOES. The independent variables are averaged over the specified time periods.

In equation (3), the time-weighted average bid-ask spread is the independent variable and is averaged over the described two-week trading periods. The independent variables are (the stock price x PIN), the proportion of quotes submitted to Nasdaq by ECNs, the proportion of trades executed through SelectNet, the proportion of trades executed with the SOES, and the lagged natural logarithm of the number of trades. The independent variables are averaged over the specified time periods. The model is:

$$\begin{aligned} VNET\_Mean_i &= \alpha + \beta_1 TWA\_Mean_i + \beta_2 Vol\_Mean_i + \beta_3 Trades\_Mean_i + \beta_4 Eptime\_Mean_i + \\ &\quad \beta_5 Ptime\_err\_Mean_i + \beta_6 ECN\_Mean_i + \beta_7 SelectNet\_Mean_i + \beta_8 SOES\_Mean_i + \varepsilon_i \end{aligned} \quad (1)$$

$$PIN_i = \alpha + \beta_1 Trades\_Mean_i + \beta_2 VNET\_Mean_i + \beta_3 ECN\_Mean_i + \beta_4 SelectNet\_Mean_i + \beta_5 SOES\_Mean_i + \varepsilon_i \quad (2)$$

$$\begin{aligned} TWA\_Mean_i &= \alpha + \beta_1 (Price\_Mean \text{ x } PIN)_i + \beta_2 Trades\_Mean_i + \beta_3 ECN\_Mean_i + \\ &\quad \beta_4 SOES\_Mean_i + \beta_5 SelectNet\_Mean_i + \varepsilon_i \end{aligned} \quad (3)$$

Equation 1: VNET_Mean on Nasdaq (N=260)

Intercept	TWA_Mean	Vol_Mean	Trades_Mean	Eptime_Mean	Ptime_err_Mean	ECN_Mean	SelectNet_Mean	SOES_Mean	Adj. R^2
0.5978	-1.8385	0.8345	1.0082	0.3897	0.0560	1.8772	-2.9599	16.4594	0.6990
(0.5290)	(0.0073)	(0.0001)	(0.0001)	(0.0001)	(0.1110)	(0.0001)	(0.0001)	(0.0008)	

Equation 2: PIN on Nasdaq (N=260)

Intercept	Trades_Mean	VNET_Mean	ECN_Mean	SelectNet_Mean	SOES_Mean	Adj. R^2
0.4834	-0.0240	-0.0183	-0.1610	0.0894	-1.1522	0.4115
(0.0001)	(0.0833)	(0.0333)	(0.0001)	(0.1886)	(0.0107)	

Equation 3: Time-Weighted Average Spreads (TWA) on Nasdaq (N=260)

Intercept	Price_Mean x PIN	Trades_Mean	ECN_Mean	SelectNet_Mean	SOES_Mean	Adj. R^2
0.2509	0.0342	-0.0705	-0.097	0.1582	0.4777	0.4660
(0.0001)	(0.0001)	(0.0001)	(0.0174)	(0.0545)	(0.4159)	

Trading Systems on depth are more pronounced with the sign of the SelectNet coefficient turning negative.

Estimates for equation 2 show a negative relationship between VNET and the probability of informed trading (PIN). Increased quote activity by ECNs and increased trade activity through SOES are associated with lower probabilities of informed trading. However, trading through SelectNet does not significantly affect informed trading.

Equation 3 results demonstrate higher numbers of trades are associated with narrower bid-ask spreads. However, higher adverse selection costs, represented as average stock price multiplied by PIN, are related to increased spreads. Although higher proportions of ECN quote activity on are associated with decreases in bid-asked spreads, higher proportions of trading through SelectNet are associated with increases in spreads.

Table 18 presents two stage least squares results for the Nasdaq, including alternative trading system effects, using the 2% threshold. Two notable differences exist between the results presented in Table 17 and those presented in Table 18. First, in equation 1, the effect of a SOES trading on depth becomes negative and insignificant. Second, the relationship between SOES trading and the probability of informed trading turns positive and significant.

Consistently in Tables 17 and 18, ECN quotation activity is associated with increased depth, lower probabilities of informed trading, and smaller bid-ask spreads. Comparatively, higher proportions of trading through SelectNet are related to decreased depth and increased spreads.

Table 18: Two Stage Least Squares Regression Results on Nasdaq with ATS using 2% Price Threshold

The following two stage least squares regression model is estimated using three simultaneous equations. In equation (1), the dependent variable is the average VNET computed for each of the following two-week trading periods: Apr 19, 1999 - Apr 30, 1999, Apr 5, 2001 - Apr 18, 2001, Apr 19, 2001 - May 2, 2001, and Apr 19, 2002 - May 2, 2002. The independent variables are the time-weighted average bid-ask spread, the lagged natural logarithm of trade volume, the lagged natural logarithm of the number of trades, the natural logarithm of the forecast of eptime, the error from the forecast of eptime, the proportion of quotes submitted to Nasdaq by Electronic Communication Networks (ECNs), the proportion of trades executed with SelectNet, and the proportion of trades executed with the Small Order Execution System (SOES). The independent variables are averaged over the same time periods as VNET.

The probability of informed trading (PIN) is the independent variable in equation (2). PIN is estimated over the detailed two-week trading periods. The independent variables are the lagged natural logarithm of the number of trades, VNET, the proportion of quotes submitted to Nasdaq by ECNs, the proportion of trades executed with SelectNet, and the proportion of trades executed with the SOES. The independent variables are averaged over the specified time periods.

In equation (3), the time-weighted average bid-ask spread is the independent variable and is averaged over the described two-week trading periods. The independent variables are (the stock price x PIN), the proportion of quotes submitted to Nasdaq by ECNs, the proportion of trades executed through SelectNet, the proportion of trades executed with the SOES, and the lagged natural logarithm of the number of trades. The independent variables are averaged over the specified time periods. The model is:

$$\text{VNET\_Mean}_i = \alpha + \beta_1\text{TWA\_Mean}_i + \beta_2\text{Vol\_Mean}_i + \beta_3\text{Trades\_Mean}_i + \beta_4\text{Eptime\_Mean}_i + \beta_5\text{Ptime\_err\_Mean}_i + \beta_6\text{ECN\_Mean}_i + \beta_7\text{SelectNet\_Mean}_i + \beta_8\text{SOES\_Mean}_i + \varepsilon_i \quad (1)$$

$$\text{PIN}_i = \alpha + \beta_1\text{Trades\_Mean}_i + \beta_2\text{VNET\_Mean}_i + \beta_3\text{ECN\_Mean}_i + \beta_4\text{SelectNet\_Mean}_i + \beta_5\text{SOES\_Mean}_i + \varepsilon_i \quad (2)$$

$$\text{TWA\_Mean}_i = \alpha + \beta_1(\text{Price\_Mean x PIN})_i + \beta_2\text{Trades\_Mean}_i + \beta_3\text{ECN\_Mean}_i + \beta_4\text{SOES\_Mean}_i + \beta_5\text{SelectNet\_Mean}_i + \varepsilon_i \quad (3)$$

Equation 1: VNET_Mean on Nasdaq (N=319)

Intercept	TWA_Mean	Vol_Mean	Trades_Mean	Eptime_Mean	Ptime_err_Mean	ECN_Mean	SelectNet_Mean	SOES_Mean	Adj. R^2
1.8566	-0.5714	0.6296	0.9905	0.0153	-0.0127	2.4596	-3.1292	-1.2668	0.4756
(0.0661)	(0.5137)	(0.0001)	(0.0001)	(0.7030)	(0.6113)	(0.0001)	(0.0001)	(0.4164)	

Equation 2: PIN on Nasdaq (N=319)

Intercept	Trades_Mean	VNET_Mean	ECN_Mean	SelectNet_Mean	SOES_Mean	Adj. R^2
0.4680	-0.0204	-0.0190	-0.1108	0.0006	0.3470	0.2743
(0.0001)	(0.1414)	(0.1375)	(0.0023)	(0.9928)	(0.0028)	

Equation 3: Time-Weighted Average Spreads (TWA) on Nasdaq (N=319)

Intercept	Price_Mean x PIN	Trades_Mean	ECN_Mean	SelectNet_Mean	SOES_Mean	Adj. R^2
0.2333	0.0314	-0.0482	-0.1220	0.2696	-0.1390	0.4186
(0.0001)	(0.0001)	(0.0001)	(0.0003)	(0.0002)	(0.3368)	

Table 19 provides two stage least squares regression estimates for the NYSE and Nasdaq using the 1% threshold. Results for equation 1 suggest NYSE listing is positively, but insignificantly related to VNET relative to Nasdaq listing. NYSE listing is associated with an increase in the probability of informed trading in equation 2. Lastly, NYSE listing is weakly associated with higher time-weighted average spreads in equation 3.

Two-stage least squares regression results for the NYSE and Nasdaq using the 2% threshold are given in Table 20. At the 2% threshold, NYSE listing is associated with lower probabilities of informed trading and larger bid-ask spreads. However, the coefficients for volume and the conditional time between trades in equation 1 have different signs in Table 19 than in Table 20. Additionally, NYSE listing no related to VNET.

In general, Tables 19 and 20 showed that NYSE listing is only consistently associated with increased time-weighted average bid-ask spreads.

6C. Conclusions

Two-stage least squares regression estimates find a positive relationship between the number of trades and VNET. Although this is consistent with the half-life model of Easley *et al.*, it contradicts evidence offered by Engle and Lange (2001).

Increased ECN quotation activity is associated with increased depth, lower probabilities of informed trading, and smaller bid-ask spreads. These relationships are consistent with the expectation that the benefit of the posting of customer limit orders

Table 19: Two Stage Least Squares Regression Results on the NYSE and Nasdaq using 1% Price Threshold

The following two stage least squares regression model is estimated using three simultaneous equations. In equation (1), the dependent variable is the average VNET computed for each of the following two-week trading periods for Nasdaq listed companies: Apr 19, 1999 - Apr 30, 1999, Apr 5, 2001 - Apr 18, 2001, Apr 19, 2001 - May 2, 2001, and Apr 19, 2002 - May 2, 2002. VNET is averaged over the following two-week trading periods for NYSE listed companies: Jan 29, 1999 - Feb 11, 1999, Jan 15, 2001 - Jan 26, 2001, Jan 29, 2001 - Feb 9, 2001, and Jan 29, 2002 - Feb 11, 2002. The independent variables are the time-weighted average bid-ask spread, the lagged natural logarithm of trade volume, the lagged natural logarithm of the number of trades, the natural logarithm of the forecast of eptime, the error from the forecast of eptime, the proportion of quotes submitted to Nasdaq by Electronic Communication Networks (ECNs), the proportion of trades executed with SelectNet, and the proportion of trades executed with the Small Order Execution System (SOES). The independent variables are averaged over the same time periods as VNET.

The probability of informed trading (PIN) is the independent variable in equation (2). PIN is estimated over the detailed two-week trading periods. The independent variables are the lagged natural logarithm of the number of trades, VNET, the proportion of quotes submitted to Nasdaq by ECNs, the proportion of trades executed with SelectNet, and the proportion of trades executed with the SOES. The independent variables are averaged over the specified time periods.

In equation (3), the time-weighted average bid-ask spread is the independent variable and is averaged over the described two-week trading periods. The independent variables are (the stock price x PIN), the proportion of quotes submitted to Nasdaq by ECNs, the proportion of trades executed with SelectNet, the proportion of trades executed with the SOES, and the lagged natural logarithm of the number of trades. The independent variables are averaged over the specified time periods. The model is:

$$\text{VNET\_Mean}_i = \alpha + \beta_1\text{TWA\_Mean}_i + \beta_2\text{Vol\_Mean}_i + \beta_3\text{Trades\_Mean}_i + \beta_4\text{Eptime\_Mean}_i + \beta_5\text{Ptime\_err\_Mean}_i + \beta_6\text{NYSE}_i + \varepsilon_i \quad (1)$$

$$\text{PIN}_i = \alpha + \beta_1\text{Trades\_Mean}_i + \beta_2\text{VNET\_Mean}_i + \beta_3\text{NYSE}_i + \varepsilon_i \quad (2)$$

$$\text{TWA\_Mean}_i = \alpha + \beta_1(\text{Price\_Mean x PIN})_i + \beta_2\text{Trades\_Mean}_i + \beta_3\text{NYSE}_i + \varepsilon_i \quad (3)$$

Equation 1: VNET_Mean on the NYSE and Nasdaq (N=668)

Intercept	TWA_Mean	Vol_Mean	Trades_Mean	Eptime_Mean	Ptime_err_Mean	NYSE	Adj. R^2
6.3468	-0.1931	-0.2277	1.3117	0.2457	0.1168	2.0041	0.0515
(0.0001)	(0.4240)	(0.2463)	(0.0008)	(0.3955)	(0.5031)	(0.1191)	

Equation 2: PIN on the NYSE and Nasdaq (N=668)

Intercept	Trades_Mean	VNET_Mean	NYSE	Adj. R^2
1.5912	0.1619	-0.2093	0.0763	0.0906
(0.0001)	(0.0001)	(0.0001)	(0.0130)	

Equation 3: Time-Weighted Average Spreads (TWA) on the NYSE and Nasdaq (N=668)

Intercept	Price_Mean x PIN	Trades_Mean	NYSE	Adj. R^2
-3.0721	0.2622	0.9657	3.3182	0.00458
(0.1660)	(0.3615)	(0.2014)	(0.0668)	

Table 20: Two Stage Least Squares Regression Results on the NYSE and Nasdaq using 2% Price Threshold

The following two stage least squares regression model is estimated using three simultaneous equations. In equation (1), the dependent variable is the average VNET computed for each of the following two-week trading periods for Nasdaq listed companies: Apr 19, 1999 - Apr 30, 1999, Apr 5, 2001 - Apr 18, 2001, Apr 19, 2001 - May 2, 2001, and Apr 19, 2002 - May 2, 2002. VNET is averaged over the following two-week trading periods for NYSE listed companies: Jan 29, 1999 - Feb 11, 1999, Jan 15, 2001 - Jan 26, 2001, Jan 29, 2001 - Feb 9, 2001, and Jan 29, 2002 - Feb 11, 2002. The independent variables are the time-weighted average bid-ask spread, the lagged natural logarithm of trade volume, the lagged natural logarithm of the number of trades, the natural logarithm of the forecast of eptime, the error from the forecast of eptime, the proportion of quotes submitted to Nasdaq by Electronic Communication Networks (ECNs), the proportion of trades executed with SelectNet, and the proportion of trades executed with the Small Order Execution System (SOES). The independent variables are averaged over the same time periods as VNET.

The probability of informed trading (PIN) is the independent variable in equation (2). PIN is estimated over the detailed two-week trading periods. The independent variables are the lagged natural logarithm of the number of trades, VNET, the proportion of quotes submitted to Nasdaq by ECNs, the proportion of trades executed with SelectNet, and the proportion of trades executed with the SOES. The independent variables are averaged over the specified time periods.

In equation (3), the time-weighted average bid-ask spread is the independent variable and is averaged over the described two-week trading periods. The independent variables are (the stock price x PIN), the proportion of quotes submitted to Nasdaq by ECNs, the proportion of trades executed with SelectNet, the proportion of trades executed with the SOES, and the lagged natural logarithm of the number of trades. The independent variables are averaged over the specified time periods. The model is:

$$\text{VNET\_Mean}_i = \alpha + \beta_1 \text{TWA\_Mean}_i + \beta_2 \text{Vol\_Mean}_i + \beta_3 \text{Trades\_Mean}_i + \beta_4 \text{Eptime\_Mean}_i + \beta_5 \text{Ptime\_err\_Mean}_i + \beta_6 \text{NYSE}_i + \varepsilon_i \qquad (1)$$

$$\text{PIN}_i = \alpha + \beta_1 \text{Trades\_Mean}_i + \beta_2 \text{VNET\_Mean}_i + \beta_3 \text{NYSE}_i + \varepsilon_i \qquad (2)$$

$$\text{TWA\_Mean}_i = \alpha + \beta_1 (\text{Price\_Mean x PIN})_i + \beta_2 \text{Trades\_Mean}_i + \beta_3 \text{NYSE}_i + \varepsilon_i \qquad (3)$$

Equation 1: VNET_Mean on the NYSE and Nasdaq (N=626)

Intercept	TWA_Mean	Vol_Mean	Trades_Mean	Eptime_Mean	Ptime_err_Mean	NYSE	Adj. R^2
6.1442	-0.3107	0.1451	0.9156	-0.0040	-0.0379	0.4592	0.3877
(0.0001)	(0.1624)	(0.0108)	(0.0001)	(0.9061)	(0.0455)	(0.2178)	

Equation 2: PIN on the NYSE and Nasdaq (626)

Intercept	Trades_Mean	VNET_Mean	NYSE	Adj. R^2
0.3645	-0.0057	-0.0166	-0.0687	0.1701
(0.0024)	(0.7415)	(0.3571)	(0.0001)	

Equation 3: Time-Weighted Average Spreads (TWA) on the NYSE and Nasdaq (626)

Intercept	Price_Mean x PIN	Trades_Mean	NYSE	Adj. R^2
-0.3799	0.0748	0.1261	1.3934	0.18192
(0.0571)	(0.0020)	(0.0769)	(0.0001)	

outweighs the costs of enhanced trader anonymity. Comparatively, higher proportions of trading through SelectNet are related to decreased depth and increased spreads. Thus, the increased trading time associated with negotiated trades appears to be more costly than the benefit of improved trade terms.

NYSE listing is associated with increased time-weighted average bid-ask spreads.

Conclusions and Future Research

Estimates of the immediate effect of decimalization on market depth show VNET decreased on the NYSE from pre-decimalization 2001 to post-decimalization 2001. This is consistent with previous findings that smaller tick sizes reduce liquidity. Comparatively, decimalization caused no immediate impact on depth on the Nasdaq. Long-term evidence of the impact of decimalization on depth differs greatly for the Nasdaq compared to the NYSE; VNET increased on the Nasdaq, but decreased on the NYSE. Therefore, prior research findings that decimalization caused tighter bid-ask spreads, resulting in lower trading costs on the NYSE are not complete and may be misleading.

The impact of Alternative Trading Systems on depth for Nasdaq listed companies has been significant. In general, higher proportions of quote activity through ECNs are related to increased depth. Comparatively, higher proportions of trading through SelectNet are related to decreased depth and increased spreads.

Estimates of the relationship between the proportions of quotations placed through ECNs and the probability of informed trading show the probability of informed trading to decrease as the proportion of ECN quotations increases. However, estimates of the relationship between the proportion of trades executed through SOES and SelectNet and the probability of informed trading are inconclusive. Together, these findings suggest that traders may consider adverse selection costs in choosing their execution venue.

Several areas of possible research arise from this study. Four possible ways in which market participants may change quotation behavior in a manner consistent with decreasing spreads are identified in this study. The ask or supply curves and bid or demand curves are presented to show how quoted volumes may increase or decrease depending on either movements along the curves or shifts in the curves. However, rationales are not offered for why these possible changes in the curves occur. What information or events cause movement up of down a curve? What is (are) the appropriate technique(s) to measure a supply or demand curve? How much shift in a curve is necessary to be considered something other than noise? In other words, if bid and ask curves are not simple, straight nonstochastic lines, but instead vibrate within some normal range, then how much vibration is should be considered noise instead of a shift?

Lastly, the effects of price or returns volatility were not considered in this work. However, market depth may be affected by changes in volatility. In the presence of positive inventory holding costs, traders may wish to quote smaller share amounts when volatility increases. Additionally, heightened volatility could cause a trader to reconsider his choice of trading venue. Differences in the speed of order execution across trading systems may cause investors to choose faster execution systems during periods of increased volatility.

References

Admati, A. and P. Pfleiderer, 1988, A Theory of Intraday Patterns: Volume and Price Variability, The Review of Financial Studies 1, 30-40.

Atkinson, William and Peter Martin, 1999, Halving the Minimum Tick Size on the NYSE, Office of Economic Analysis, U.S. Securities and Exchange Commission Working Paper.

Bacidore, 1997, The Impact of Decimalization on Market Quality: An Empirical Investigation of the Toronto Stock Exchange, Journal of Financial Intermediation 6, 96-120.

Bacidore, Battalio, and Jennings, 2001, Order Submission Strategies, Liquidity Supply, and Trading in Pennies on the New York Stock Exchange, N.Y.S.E Working Paper.

Barclay, J., W. Christie, J. Harris, E. Kandel, and P. Schultz, 1999, Effects of Market Reform on the Trading Costs and Depths of Nasdaq Stocks, Journal of Finance 54, 1-33.

Bentson, George and Robert Hagerman, 1974, Determinants of Bid-Ask Spreads in the Over-the-Counter Market, Journal of Financial Economics 1, December, 353-364.

Benveniste, L., Marcus, A. and W. Wilhelm, 1992, What's Special about the Specialist? Journal of Financial Economics 32, 61-86.

Bessembinder, Hendrik, 2000, Tick Size, Spreads and Liquidity: An Analysis of Nasdaq Securities Trading Near Ten Dollars, Journal of Financial Intermediation 9, 213-239.

Bollen, Nicolas and Robert Whaley, 1998, Are 'Teenies' Better?, Journal of Portfolio Management 25, 10-24.

Chakravarty and Robert Wood, 2000, The Effect of Decimal Trading Market Liquidity, University of Memphis Working Paper and various Nasdaq Economic Research Internal Memos.

Chordia, Tarun, Richard Roll, and Avanidhar Subrahmanyam, 2001, Common Determinants of Liquidity and Trading, The Research Foundation of AIMR.

Christie, William, Jeffrey Harris, and Eugene Kandel, 1999, The Impact of A Lower Tick Size on Quoting Behavior, Trading Costs on Nasdaq, Vanderbilt University Working Paper.

Conrad, Jennifer, Kevin Johnson and Sunil Wahal, 2001, Alternative Trading Systems, working paper, University of North Carolina at Chapel Hill, Aronson & Partners and Emory University.

Daves, Phillip, James Wansley, and Rongrong Zhang, 2003, Reported Trading Volume on the NYSE and Nasdaq, The University of Tennessee Working Paper.

De Jong, F., Nijman, Th., and A. Röell, 1996, Price Effects of Trading and Components of the Bid-Ask Spread on the Paris Bourse, Journal of Empirical Finance 3, 193-213.

Dyl, Edward and Anne-Marie Anderson, 2003, Market Structure and Trading Volume, The University of Arizona Working Paper.

Easley, David, Robert Engle, Maureen O'Hara, and Liuren Wu, 2001, Time Varying Arrival Rates of Informed and Uninformed Trades, working paper, Cornell University, New York University, Cornell University, and Fordham University.

Easley,David, and Maureen O'Hara, 1987, Price, Trade Size and Information in Securities Markets, Journal of Financial Economics 19, 69-90.

Easley,David, and Maureen O'Hara, 1992, Time and the Process of Security Price Adjustment, Journal of Finance 577-606.

Easley,D., N. Kiefer, M. O'Hara, and J. Paperman, 1996, Liquidity, Information, Infrequently Traded Stocks, Journal of Finance 51, 1405-1436.

Economides, N. and R. Schwartz, 1995, Equity Trading practices and Market Structure: Assessing Asset Managers' Demand for Immediacy, Working Paper, No. EC-95-08, Stern School of Business, New York University, August.

Engle, Robert and Joe Lange, 2001, Predicting VNET: A Model of the Dynamics of Market Depth, manuscript, New York University and Federal Reserve Board.

Engle, Robert and J. Russell, 1997, Forecasting the Frequency of Changes in the Quoted Foreign Exchange Prices with the Autoregressive Conditional Duration Model, Journal of Empirical Finance 4, 187-212.

Foster, F. and S. Viswanathan, 1995, Can Speculative Trading Explain the Volume-Volatility Relation? Journal of Business and Economic Statistics 13, 379-408.

Garfinkel, J., and M. Nimalendram, 1998, Market Structure and Trader Anonymity: An Analysis of Insider Trading, Working Paper, Loyola University of Chicago and University of Florida, September.

Grammig, Joachim, Dirk Schiereck, and Erik Theissen, 2001, Knowing Me, Knowing You: Trader Anonymity and Informed Trading in Parallel Markets, Journal of Financial Markets 4, 385-412.

Griffiths, Mark, Brian Smith, Alasdair Turnbull, and Robert W. White, 1998, The Role of Tick Size in Upstairs Trading and Downstairs Trading, Journal of Financial Intermediation 7, 393-417.

Harris, Lawrence, 1997, Decimalization: A Review of the Arguments and Evidence, USC Working Paper.

Hasbrouck, J., 1988, Trades, Quotes, Inventories, and Information, Journal of Financial Economics 22, 229-252.

Hasbrouck, Joel and Duane Seppi, 2001, Common Factors in Prices, Order Flows, and Liquidity, Journal of Financial Economics 59, 383-411.

Huang, Roger, 2002, The Quality of ECN and Nasdaq Market Maker Quotes, Journal of Finance 57, 1285-1319.

Lee, Charles and Mark Ready, 1991, Inferring Trade Direction from Intraday Data, Journal of Finance 46, 733-746.

LaPorta, Rafael, Florencio Lopez-De-Silanes, Andrei Shleifer, and Robert Vishny, 1997, Legal Determinants of External Finance, Journal of Finance 52, 1131-1150.

MacKinnon and Nimeroff, 1999, Liquidity and Tick Size: Does Decimalization Matter?, Journal of Financial Research 22, 287-299.

Madhavan, A., and M.Cheng, 1997, In Search of Liquidity: Block Trades in the Upstairs and Downstairs Market, Review of Financial Studies 10, 175-203.

McInish, T. and R. Wood, 1992, An Analysis of Intraday Patterns in Bid/Ask Spreads for NYSE Stocks, Journal of Finance 47, 753-764.

Nasdaq Association of Securities Dealers, Nasdaq National Market Execution System, NASD Notice To Members 00-30, May 2000.

Nasdaq Economic Research, 2001, The Impact of Decimalization on the Nasdaq Stock Market, Final Report to the SEC, June 11th.

Nasdaq Trader Manual, www.nasdaqtrader.com/trader/tradingservices/marketwatch/tradermanual/tradermanual.stm

Porter, D. and D. Weaver, 1997, Tick Size and Market Quality, Financial Management 26, 5-26.

Securities and Exchange Commission Release No.34-42360, File No. 4-430, January 28, 2000, Division of Market Regulation: Order Directing the Exchanges and NASD to Submit a Decimalization Implementation Plan.

Rhodes-Kropf, M., 1998, Price Improvements in Dealership Markets, Working Paper, Columbia University, October.

Schwartz, R. and B. Steil, 1996, Equity Trading III: Institutional Investor Trading Practices and Preferences. In: Steil, B.al. (Eds.), The European Equity Markets, Brookings Institution, London.

Seppi, D., 1990, Equilibrium Block Trading and Asymmetric Information, Journal of Finance 45, 73-94.

Smith, Jeffrey, 1998, The Effects of Order Handling Rules and 16ths on Nasdaq: A Cross-Sectional Analysis, Nasdaq Working Paper.

Smith, Jeffrey, James Selway and D. Timothy McCormick, 1998, The Nasdaq Stock Market: Historical Background and Current Operation, NASD Working Paper 98-01,NASD Department of Economic Research.

Stoll, Hans, 1978, The Pricing of a Security Dealer Services: An Empirical Study of Nasdaq Stocks, Journal of Finance 33, September, 1153-1172.

Strother, Shawn, James Wansley, and Phillip Daves, 2003, The Impact of Electronic Communication Networks on the Components of the Bid/Ask Spread, The University of Tennessee Working Paper.

Appendix

Appendix 1 Table A: The Probability of Informed Trading (PIN) for Nasdaq Companies During 1999 Period

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

1999	ALPHA	DELTA	ETA	MU	PIN
ADSK	1.0000	0.1998	500.8602	197.8355	0.1649
	(0.0000)	(0.1166)	(44.8510)	(35.4359)	
ALKS	0.3000	0.6742	76.7714	111.8578	0.1794
	(0.1871)	(0.3502)	(8.6395)	(48.1539)	
ALXN	0.2002	0.0000	23.7207	50.7499	0.1764
	(0.1511)	(0.0000)	(2.4150)	(2.4088)	
AMAT	1.0000	0.2193	126.3098	14.3791	0.0539
	(0.0000)	(0.1616)	(50.7801)	(9.0807)	
AMKR	0.3000	0.3333	287.4118	431.5882	0.1838
	(0.1871)	(0.3514)	(41.0910)	(117.3989)	
ANAD	0.4000	0.7500	148.4375	169.3125	0.1858
	(0.2000)	(0.2795)	(19.4243)	(33.1505)	
ANSR	0.4000	0.7500	75.6250	75.3749	0.1662
	(0.2000)	(0.2795)	(11.8152)	(15.1749)	
APAC	0.3000	0.6667	47.1765	113.8235	0.2657
	(0.1871)	(0.3514)	(11.1547)	(12.3310)	
APLX	0.2000	0.4997	52.9447	99.5532	0.1583
	(0.1633)	(0.4563)	(9.1990)	(27.6922)	
ASCA	0.1726	0.0000	3.6030	12.7113	0.2334
	(0.2287)	(0.0000)	(1.2527)	(9.7880)	
ASFC	0.4000	0.0000	154.0629	99.9378	0.1148
	(0.1851)	(0.0000)	(9.9821)	(33.4444)	
ATGI	0.4816	0.0000	5.0033	14.5211	0.4114
	(0.2094)	(0.0000)	(1.9022)	(2.8750)	
AULT	0.3004	0.3344	21.1746	33.1259	0.1903
	(0.1869)	(0.3533)	(3.4459)	(5.9862)	
AVTR	0.4313	0.7482	7.5317	11.2127	0.2430
	(0.2228)	(0.3051)	(1.0378)	(3.5829)	
BAMM	0.4000	0.7499	299.8752	257.6238	0.1466
	(0.2000)	(0.2796)	(29.9175)	(73.6388)	
BBBY	0.3000	0.6667	518.2941	304.0392	0.0809
	(0.1871)	(0.3514)	(46.9235)	(80.6226)	
BITS	0.3968	0.4053	5.5189	8.3063	0.2299
	(0.7617)	(0.6028)	(2.4333)	(8.2595)	
BKUN	0.6028	0.4902	42.2701	52.0267	0.2706
	(0.1986)	(0.2511)	(9.1494)	(14.3408)	
BSTE	0.4461	0.7367	18.1061	18.1285	0.1826
	(0.1957)	(0.2969)	(3.0778)	(3.4271)	
BTRN	0.2858	0.0000	3.5832	19.4117	0.4363
	(0.2259)	(0.0000)	(1.1917)	(5.9497)	
BVAS	0.6758	1.0000	7.4155	7.6488	0.2585
	(0.1736)	(0.0000)	(1.9880)	(1.7760)	
CAND	0.1000	0.0000	106.0526	415.9474	0.1639
	(0.1134)	(0.0000)	(29.2033)	(29.2033)	

Appendix 1 Table A Continued

$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$

1999	ALPHA	DELTA	ETA	MU	PIN
CBUK	0.9765	0.0000	25.4842	21.2344	0.2892
	(0.0211)	(0.0000)	(7.0506)	(12.5853)	
CELL	0.4923	0.4740	754.3731	741.7081	0.1949
	(0.2931)	(0.0015)	(129.8488)	(951.7849)	
CENT	0.3000	1.0000	49.0000	105.6667	0.2444
	(0.1732)	(0.0000)	(3.9958)	(15.1898)	
CHIR	0.6990	0.4277	356.0024	182.7021	0.1521
	(0.1860)	(0.2424)	(21.8809)	(29.4974)	
COMS	1.0000	0.0000	109.1689	5.7679	0.0257
	(0.0000)	(0.0000)	(49.8822)	(9.4877)	
CSCO	1.0000	1.0000	122.0130	12.0570	0.0471
	(0.3706)	(0.0000)	(35.3776)	(20.4034)	
DAVX	0.3925	0.7448	63.1129	75.1022	0.1893
	(0.2014)	(0.3401)	(7.6663)	(41.1421)	
DIAN	1.0000	0.6487	1.0728	2.8543	0.5709
	(0.0000)	(0.2143)	(0.6763)	(0.7242)	
DRTE	0.9985	0.0000	88.8556	70.3174	0.2832
	(0.0011)	(0.0000)	(12.8495)	(28.7249)	
DRYR	0.5002	0.3998	41.5990	45.9882	0.2166
	(0.2039)	(0.2825)	(6.3920)	(9.7359)	
DSTM	0.9339	0.0000	72.1375	73.5651	0.3226
	(0.0276)	(0.0000)	(11.3669)	(20.9380)	
DTPI	0.2000	0.5001	33.0554	69.9400	0.1746
	(0.1632)	(0.4558)	(5.9704)	(26.4483)	
DUCK	0.5157	0.0000	2.8098	3.9695	0.2670
	(0.2439)	(0.0000)	(0.6657)	(1.6215)	
EMMS	0.4275	0.5000	55.6097	62.8834	0.1946
	(2.2848)	(0.3210)	(48.4052)	(171.1190)	
EXBT	0.2007	0.5003	36.2158	52.6688	0.1273
	(0.1629)	(0.4601)	(4.9159)	(16.2440)	
FSII	0.2000	1.0000	27.3333	66.6656	0.1961
	(0.1512)	(0.0000)	(3.2517)	(9.8143)	
FUTR	0.2222	0.4999	15.3136	61.6962	0.3092
	(0.1857)	(0.4772)	(5.0700)	(29.4326)	
GLFD	0.3061	0.0000	37.6436	45.4456	0.1560
	(0.1685)	(0.0000)	(5.5637)	(15.9712)	
HGSI	0.3942	0.5074	40.1466	38.3209	0.1584
	(0.1981)	(0.3399)	(2.9710)	(6.2779)	
HLYW	1.0000	0.5957	149.5896	75.1247	0.2007
	(0.0000)	(0.1581)	(34.9684)	(16.3702)	
HMSY	0.7413	0.6445	53.1304	39.8476	0.2175
	(0.7053)	(0.3103)	(15.7049)	(16.8122)	
HOFF	0.3013	0.6677	18.2339	23.6750	0.1636
	(0.1868)	(0.3499)	(2.4579)	(3.6483)	
HRLY	0.1046	0.0000	14.5562	24.7345	0.0816
	(0.1143)	(0.0000)	(2.0608)	(1.7408)	
HUBG	0.3899	0.7563	7.5173	21.4574	0.3575
	(0.1775)	(0.3079)	(2.6133)	(8.2343)	
INSP	1.0000	1.0000	223.0081	67.5124	0.1315
	(0.0000)	(0.0000)	(86.9903)	(21.6270)	

Appendix 1 Table A Continued

$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$

1999	ALPHA	DELTA	ETA	MU	PIN
INTC	1.0000	0.2036	120.9566	11.6437	0.0459
	(0.0000)	(0.1329)	(46.5945)	(8.4449)	
ITIG	0.9999	1.0000	106.2966	67.7741	0.2417
	(0.0000)	(0.0000)	(16.8812)	(41.7715)	
LARS	0.2981	0.0000	21.1984	26.8457	0.1588
	(0.1727)	(0.0000)	(2.2567)	(7.2221)	
LNCB	0.3989	0.4986	8.7611	34.0376	0.4366
	(0.1973)	(0.3329)	(3.2631)	(12.6709)	
LTRE	0.4385	0.7629	6.1477	13.0099	0.3169
	(0.1900)	(0.2912)	(1.8796)	(2.1914)	
LUFK	0.5007	0.5988	10.2017	20.3640	0.3332
	(0.2031)	(0.2824)	(2.0928)	(4.4702)	
MDEA	0.1000	0.0000	13.0000	66.0000	0.2025
	(0.1134)	(0.0000)	(4.2218)	(4.2218)	
MEDI	1.0000	0.3865	326.7923	149.6996	0.1864
	(0.0000)	(0.2114)	(65.3908)	(23.7395)	
MEDX	0.7289	1.0000	24.4955	19.2184	0.2224
	(0.2039)	(0.0000)	(2.5086)	(4.0981)	
MINI	0.5000	0.6000	28.1999	62.3992	0.3562
	(0.2041)	(0.2829)	(4.9570)	(12.3116)	
MSFT	0.0000	0.0264	106.6019	4.2585	0.0000
	(0.0000)	(0.3975)	(44.5322)	(9.0520)	
NATR	0.4000	0.7501	31.7503	44.4985	0.2189
	(0.2000)	(0.2795)	(4.6917)	(9.6788)	
NEOG	1.0000	1.0000	5.8000	9.0000	0.4369
	(0.0000)	(0.0000)	(0.9192)	(1.3416)	
NETM	0.2000	0.5000	84.9444	142.5555	0.1437
	(0.1633)	(0.4564)	(11.7464)	(16.2446)	
NTAP	0.9988	1.0000	381.4040	175.9140	0.1872
	(0.0008)	(0.0000)	(61.3867)	(103.8696)	
ODET	0.0839	1.0000	11.7790	19.0657	0.0636
	(0.0457)	0.0000	(2.0323)	(3.4794)	
OPTI	0.2989	0.6655	12.8361	35.5530	0.2928
	(0.1841)	(0.3644)	(3.1515)	(11.7218)	
ORCL	1.0000	0.1743	133.4788	18.7469	0.0656
	(0.0000)	(0.1760)	(50.7477)	(11.7143)	
OSIP	0.5029	0.2034	38.5351	26.7027	0.1484
	(0.2041)	(0.2320)	(2.8335)	(3.0947)	
PCCC	0.3000	0.6667	59.2941	86.7059	0.1799
	(0.1871)	(0.3514)	(9.4101)	(24.2078)	
PCDI	0.2757	1.0000	5.4002	9.4287	0.1940
	(0.1626)	(0.0000)	(1.3710)	(2.6587)	
PENX	0.2486	0.5685	7.3603	15.2050	0.2043
	(0.1195)	(0.5145)	(2.1030)	(4.1276)	
PETM	1.0000	0.6395	208.1913	137.9749	0.2489
	(0.0000)	(0.1602)	(46.5840)	(46.8620)	
PLFE	0.3000	1.0000	16.8235	32.8417	0.2265
	(0.1732)	(0.0000)	(3.1340)	(4.1332)	
PRST	0.2000	0.5000	115.2778	288.7222	0.2003
	(0.1633)	(0.4564)	(22.5709)	(78.6677)	

Appendix 1 Table A Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

1999	ALPHA	DELTA	ETA	MU	PIN
PSFT	1.0000	1.0000	225.2957	73.3028	0.1399
	(0.3706)	(0.0000)	(81.5500)	(53.6720)	
PTEN	0.9971	0.0000	354.0284	167.8184	0.1912
	(0.0011)	(0.0000)	(60.8736)	(175.0442)	
QADI	0.8919	0.0000	24.1179	25.3348	0.3190
	(0.0939)	(0.0000)	(8.4198)	(27.4412)	
QDIN	0.1111	0.0000	12.2941	76.7059	0.2574
	(0.1283)	(0.0000)	(2.7610)	(2.7610)	
RCCC	0.2000	0.5000	15.8333	47.6667	0.2314
	(0.1633)	(0.4564)	(4.0485)	(4.0227)	
REMC	0.2000	1.0000	67.4444	153.0556	0.1850
	(0.1512)	(0.0000)	(10.4957)	(20.0382)	
RGBK	0.3000	0.3333	241.5883	208.7453	0.1147
	(0.1871)	(0.3514)	(16.3293)	(80.4115)	
RICK	0.2000	0.0000	29.6667	113.3333	0.2764
	(0.1512)	(0.0000)	(8.7148)	(41.0255)	
SANM	0.5000	0.4000	589.2000	356.8000	0.1315
	(0.2041)	(0.2828)	(63.4209)	(87.5359)	
SCFS	0.7880	1.0000	18.7955	14.4783	0.2328
	(0.1848)	(0.0000)	(2.0964)	(4.0684)	
SCSC	0.1000	1.0000	13.6842	72.3158	0.2090
	(0.1134)	(0.0000)	(5.1470)	(5.1470)	
SMXC	0.1972	0.0000	10.1906	28.4880	0.2161
	(0.1465)	0.0000	(2.6401)	(11.7357)	
SNAP	0.5000	1.0000	7.4667	29.7333	0.4989
	(0.1890)	(0.0000)	(1.6919)	(4.0892)	
SOTR	0.5006	0.1998	235.8374	176.0331	0.1574
	(0.2029)	(0.2295)	(20.5197)	(32.2628)	
SPLN	0.8237	1.0000	373.0816	273.4334	0.2318
	(0.0848)	(0.0000)	(46.8279)	(88.8527)	
TACT	0.4976	0.3971	13.0952	33.5832	0.3895
	(0.1967)	(0.2926)	(3.9833)	(6.5668)	
TACX	0.3333	0.0000	5.9336	35.4010	0.4986
	(0.1924)	(0.0000)	(1.9629)	(12.8018)	
TECU	0.3000	0.3335	106.7651	135.2353	0.1596
	(0.1871)	(0.3514)	(14.5229)	(15.8829)	
THRD	0.0000	1.0000	10.9444	0.0000	0.0000
	(0.0000)	(0.0000)	(2.7657)	0.0000	
TOPP	0.2000	0.0000	174.6543	192.2652	0.0992
	(0.1773)	(0.0000)	(28.6164)	(131.7083)	
TRAC	0.9999	0.0000	203.9739	111.3267	0.2144
	(0.0013)	(0.0000)	(190.7445)	(1336.0728)	
TWMC	0.5000	0.0000	276.5333	227.2667	0.1704
	(0.1890)	(0.0000)	(46.7406)	(51.3398)	
VTSS	0.5710	0.0000	867.7454	300.7164	0.0900
	(0.1781)	(0.0000)	(51.2591)	(63.2762)	
VNWK	0.3003	0.4584	128.3694	204.3168	0.1929
	(0.1872)	(0.3794)	(21.6421)	(63.4258)	
WCOM	1.0000	0.2978	124.8608	13.5210	0.0514
	(0.0000)	(0.1919)	(48.6859)	(8.0834)	

Appendix 1 Table A Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

1999	ALPHA	DELTA	ETA	MU	PIN
WORK	0.3057	1.0000	164.9077	88.4666	0.0758
	(0.1901)	(0.0000)	(15.7283)	(25.6911)	
YHOO	1.0000	0.1689	124.4077	12.8124	0.0490
	(0.0000)	(0.1114)	(49.0095)	(6.6605)	
ZIGO	0.7889	0.8733	13.5423	29.0464	0.4583
	(0.1774)	(0.1524)	(2.5300)	(8.3725)	

Appendix 1 Table B: The Probability of Informed Trading (PIN) for Nasdaq Companies During 2001 Pre-Decimalization Period

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

Pre 2001	ALPHA	DELTA	ETA	MU	PIN
ADSK	1.0000	0.4000	557.6799	188.5736	0.1446
	(0.0000)	(0.1567)	(94.0554)	(38.2804)	
ALKS	1.0000	0.0000	448.2128	261.9586	0.2261
	(0.0000)	(0.0000)	(52.7771)	(54.0856)	
ALXN	0.3000	0.0000	293.1176	230.5490	0.1055
	(0.1732)	(0.0000)	(13.9863)	(66.6229)	
AMAT	1.0000	0.8158	1.4015	0.0350	0.0123
	(0.0000)	(0.0696)	(0.5537)	(0.0359)	
AMKR	1.0000	0.0000	462.5829	234.8154	0.2024
	(0.0000)	(0.0000)	(66.6417)	(66.2561)	
ANAD	1.0000	0.4790	331.9240	130.5865	0.1644
	(0.0000)	(0.1666)	(85.7046)	(29.8009)	
ANSR	0.3915	0.0000	100.8138	54.9041	0.0963
	(0.5240)	(0.0000)	(18.8160)	(53.1485)	
APAC	0.2997	1.0000	41.0052	63.0199	0.1872
	(0.1725)	(0.0000)	(6.7505)	(14.8941)	
APLX	0.2003	1.0000	22.4998	28.9553	0.1142
	(0.1512)	(0.0000)	(3.2440)	(5.4021)	
ASCA	0.2999	0.0000	11.7073	35.9664	0.3154
	(0.1726)	(0.0000)	(3.4944)	(14.6117)	
ASFC	0.4479	0.4561	320.2121	129.2265	0.0829
	(0.6864)	(0.6799)	(52.3829)	(88.5667)	
ATGI	0.4437	0.6716	15.9326	31.8581	0.3073
	(0.5065)	(1.0251)	(7.6803)	(22.5799)	
AULT	0.6995	0.8570	10.6221	19.6637	0.3930
	(0.1861)	(0.1712)	(2.8304)	(6.0654)	
AVTR	0.2230	1.0000	4.5615	15.3931	0.2734
	(0.1694)	(0.0000)	(1.3981)	(3.4402)	
BAMM	0.2000	0.5000	25.6111	83.8886	0.2467
	(0.1633)	(0.4564)	(7.0653)	(20.7639)	
BBBY	1.0000	1.0000	276.4700	92.7980	0.1437
	(0.3706)	(0.0000)	(91.3118)	(44.0543)	
BITS	0.3834	0.6691	13.8813	13.9205	0.1613
	(0.1969)	(0.7346)	(3.2640)	(3.5446)	
BKUN	0.0000	(0.0000)	54.9000	2.9127	0.0000
	0.0000	0.0000	(14.6771)	(2.2085)	
BSTE	0.4979	0.0000	172.2494	177.3396	0.2040
	(0.1672)	(0.0000)	(26.8401)	(65.9292)	
BTRN	0.9851	1.0000	18.4420	20.8460	0.3576
	(0.0077)	(0.0000)	(3.2229)	(14.6474)	
BVAS	0.3000	1.0000	14.3529	32.6454	0.2544
	(0.1732)	(0.0000)	(2.2788)	(4.3986)	
CAND	0.7839	0.6502	12.2296	8.2168	0.2084
	(0.1487)	(0.3005)	(2.9749)	(3.4449)	

Appendix 1 Table B Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

Pre 2001	ALPHA	DELTA	ETA	MU	PIN
CBUK	0.4989	0.7996	21.7512	50.5069	0.3668
	(0.1999)	(0.2345)	(5.7819)	(10.6698)	
CELL	0.7915	0.3712	183.9129	115.8219	0.1995
	(0.1557)	(0.2223)	(23.1513)	(18.9936)	
CENT	0.8004	0.0000	55.1212	30.9334	0.1834
	(0.5221)	(0.0000)	(8.1078)	(12.3918)	
CHIR	1.0000	1.0000	461.8263	195.0045	0.1743
	(0.3706)	(0.0000)	(64.8167)	(0.0000)	
COMS	1.0000	1.0000	223.4768	69.3675	0.1343
	(0.3706)	(0.0000)	(73.2144)	(34.9676)	
CSCO	0.1268	0.0983	101.9378	1.5385	0.0010
	(0.0518)	(0.5676)	(45.0784)	(7.4189)	
DAVX	0.5007	0.8118	48.1320	30.4308	0.1366
	(0.1943)	(0.2415)	(5.5311)	(5.5399)	
DIAN	0.3976	0.0000	24.0927	33.2352	0.2152
	(0.1805)	(0.0000)	(4.6341)	(11.6128)	
DRTE	0.2000	0.0000	276.1111	202.3889	0.0683
	(0.1512)	(0.0000)	(21.6498)	(17.7718)	
DRYR	0.2000	0.0000	89.1666	144.3326	0.1393
	(0.1512)	(0.0000)	(8.6705)	(56.2155)	
DSTM	0.5000	0.6000	30.9335	45.6664	0.2696
	(0.2041)	(0.2829)	(2.2117)	(8.6645)	
DTPI	1.0000	0.1795	178.8647	74.2308	0.1718
	(0.0000)	(0.0887)	(26.9953)	(19.6593)	
DUCK	0.7660	0.8448	1.3542	5.4391	0.6060
	(0.2477)	(0.2129)	(0.5822)	(1.7694)	
EMMS	1.0000	0.2026	169.1063	78.8730	0.1891
	(0.0000)	(0.1187)	(26.1070)	(20.8360)	
EXBT	0.6094	0.6458	59.2778	61.2797	0.2395
	(0.1652)	(0.2384)	(13.0325)	(19.2012)	
FSII	0.4883	0.5798	129.1880	92.0013	0.1481
	(0.2144)	(0.3600)	(14.9839)	(36.7680)	
FUTR	0.4373	0.7411	4.5518	10.9435	0.3445
	(0.2282)	(0.3065)	(0.9573)	(2.1470)	
GLFD	0.4868	0.3429	110.2082	74.1224	0.1407
	(0.1761)	(0.3522)	(10.3376)	(27.4440)	
HGSI	1.0000	0.1508	151.1401	27.1106	0.0823
	(0.0000)	(0.1609)	(56.9194)	(12.0689)	
HLYW	0.4984	0.7492	37.1162	59.4807	0.2854
	(0.2408)	(0.3075)	(9.9333)	(20.0978)	
HMSY	0.3999	0.4999	6.5632	24.6871	0.4293
	(0.1998)	(0.3231)	(1.8905)	(5.9618)	
HOFF	0.4005	0.2510	135.7311	138.4077	0.1696
	(0.1985)	(0.2665)	(21.2994)	(21.0868)	
HRLY	0.2759	0.3739	18.3734	21.5764	0.1394
	(0.1665)	(0.3648)	(3.1372)	(7.6271)	
HUBG	0.6885	0.5766	2.2872	8.3167	0.5559
	(0.1866)	(0.2450)	(0.8758)	(1.2590)	
INSP	1.0000	1.0000	753.0097	370.2928	0.1974
	(0.3706)	(0.0000)	(41.7522)	(2.7751)	

Appendix 1 Table B Continued

$$PIN = \frac{\mu(1 - P_n(t))}{2\varepsilon + \mu(1 - P_n(t))}$$

Pre 2001	ALPHA	DELTA	ETA	MU	PIN
INTC	0.0000	0.0843	104.3865	2.4147	0.0000
	(0.0000)	(0.0541)	(45.5961)	(2.1837)	
ITIG	0.2858	0.5852	14.6105	30.7180	0.2310
	(0.1790)	(0.5712)	(6.0318)	(10.6382)	
LARS	0.2957	0.6615	8.8622	32.7224	0.3531
	(0.1732)	(0.4055)	(3.4478)	(16.0201)	
LNCB	1.0000	1.0000	1.4000	2.4000	0.4615
	(0.0000)	(0.0000)	(0.8641)	(1.1888)	
LTRE	0.7487	1.0000	199.3970	109.6291	0.1707
	(0.1236)	(0.0000)	(31.8773)	(26.1068)	
LUFK	0.2951	0.3389	7.1633	38.2017	0.4404
	(0.1789)	(0.3352)	(3.9095)	(17.3566)	
MDEA	0.4008	0.7505	40.0102	52.3411	0.2077
	(0.1973)	(0.2918)	(8.4817)	(14.6717)	
MEDI	1.0000	1.0000	192.3050	49.2229	0.1135
	(0.0000)	(0.0000)	(66.2322)	(17.9382)	
MEDX	1.0000	0.1743	13.2330	14.2872	0.3506
	(0.0000)	(0.1763)	(6.2310)	(9.4032)	
MINI	0.3127	0.0000	99.4027	76.4033	0.1073
	(0.1588)	(0.0000)	(10.0505)	(7.1692)	
MSFT	0.0000	0.1772	104.9646	2.8876	0.0000
	(0.0000)	(0.1471)	(45.6104)	(4.1302)	
NATR	0.3934	0.7451	19.9620	32.4778	0.2424
	(0.1942)	(0.3549)	(5.2353)	(13.4304)	
NEOG	0.4998	0.3999	21.0043	28.7929	0.2552
	(0.2035)	(0.2840)	(4.2669)	(4.4617)	
NETM	0.3999	0.7435	44.3822	58.8530	0.2096
	(0.1997)	(0.2891)	(7.7022)	(15.3405)	
NTAP	1.0000	0.0510	122.7426	12.5140	0.0485
	(0.0000)	(0.0603)	(47.0955)	(9.0977)	
ODET	1.0000	11.7790	19.0657	0.0636	0.0017
	0.0000	2.0323	3.4794	0.0000	
OPTI	0.4023	0.7494	10.3667	25.2688	0.3290
	(0.1975)	(0.2800)	(2.5409)	(8.0488)	
ORCL	1.0000	0.0698	105.6422	3.1161	0.0145
	(0.0000)	(0.3519)	(42.7846)	(4.2062)	
OSIP	0.6000	0.1667	502.0715	300.0948	0.1520
	(0.2000)	(0.1965)	(47.7028)	(71.7223)	
PCCC	0.9990	1.0000	56.6493	40.3947	0.2626
	(0.0021)	(0.0000)	(9.5344)	(27.8340)	
PCDI	0.2018	0.5002	4.8284	18.5503	0.2794
	(0.1640)	(0.4564)	(1.3736)	(1.3704)	
PENX	0.1000	0.0000	7.2105	40.7895	0.2205
	(0.1134)	(0.0000)	(2.5079)	(2.5079)	
PETM	0.6000	1.0000	123.3571	102.3095	0.1992
	(0.1852)	(0.0000)	(15.4731)	(21.1385)	
PLFE	0.3460	0.2893	28.4626	27.9632	0.1453
	(0.2327)	(0.3944)	(3.1729)	(5.8427)	
PRST	0.2000	0.0000	123.6667	106.8333	0.0795
	(0.1512)	(0.0000)	(10.9785)	(23.5936)	

Appendix 1 Table B Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

Pre 2001	ALPHA	DELTA	ETA	MU	PIN
PSFT	1.0000	0.4811	144.6308	23.8970	0.0763
	(0.0000)	(0.1900)	(53.8062)	(12.7084)	
PTEN	1.0000	0.2000	440.2871	203.3467	0.1876
	(0.0000)	(0.1171)	(55.3260)	(33.6468)	
QADI	0.1000	1.0000	15.7895	55.2105	0.1488
	(0.1134)	(0.0000)	(1.6520)	(1.6520)	
QDIN	0.3783	1.0000	3.0303	6.8889	0.3007
	(0.2524)	(0.0000)	(1.0359)	(3.7903)	
RCCC	0.5954	0.1680	97.5919	103.3239	0.2396
	(0.1800)	(0.2007)	(11.3763)	(21.0604)	
REMC	1.0000	0.5573	276.6471	104.0731	0.1583
	(0.0000)	(0.1575)	(37.3252)	(21.7218)	
RGBK	1.0000	0.5666	648.8331	186.0631	0.1254
	(0.0000)	(0.1826)	(31.1117)	(47.5279)	
RICK	0.1000	0.0000	2.3684	23.6316	0.3328
	(0.1134)	(0.0000)	(0.5813)	(0.5813)	
SANM	1.0000	0.4311	170.4733	36.6030	0.0969
	(0.0000)	(0.1902)	(64.0270)	(14.4340)	
SCFS	0.4414	0.2275	31.8812	44.2589	0.2345
	(0.2188)	(0.2583)	(6.4011)	(19.7936)	
SCSC	0.6570	0.1557	32.3582	24.4789	0.1991
	(0.2127)	(0.1989)	(5.0983)	(6.4345)	
SMXC	0.1987	0.0000	3.4005	11.5675	0.2526
	(0.1488)	0.0000	(1.2105)	(3.3546)	
SNAP	0.4102	0.5150	3.9969	10.2541	0.3448
	(0.2034)	(0.3172)	(0.7930)	(2.5262)	
SOTR	1.0000	0.4555	527.8953	178.6719	0.1447
	(0.0000)	(0.1939)	(63.1407)	(36.2706)	
SPLN	0.3000	0.6667	56.3529	155.3137	0.2925
	(0.1871)	(0.3514)	(10.8689)	(46.2224)	
TACT	0.2500	0.0000	5.1429	28.8571	0.4122
	(0.1936)	(0.0000)	(1.2149)	(4.1804)	
TACX	0.3522	0.7714	1.5656	3.8868	0.3042
	(0.7045)	(0.8893)	(1.4489)	(3.0096)	
TECU	0.5000	0.2000	141.7333	124.2670	0.1798
	(0.2041)	(0.2309)	(17.0652)	(25.8195)	
THRD	0.0000	1.0000	2.7500	0.0000	0.0000
	(0.0000)	(0.0000)	(1.1815)	(0.0000)	
TOPP	0.5933	0.8319	136.8006	87.4691	0.1594
	(0.2214)	(0.1930)	(15.1583)	(26.4955)	
TRAC	0.3994	1.0000	46.1375	55.6399	0.1941
	(0.1839)	(0.0000)	(7.5007)	(8.3615)	
TWMC	0.4368	0.7491	43.0531	33.4097	0.1449
	(0.1785)	(0.3063)	(5.5262)	(4.4931)	
VTSS	1.0000	0.1182	119.1733	10.6643	0.0428
	(0.0000)	(0.0965)	(46.8813)	(6.2890)	
VNWK	0.5000	0.4000	121.0668	102.5319	0.1747
	(0.2041)	(0.2828)	(16.3415)	(17.9402)	
WCOM	1.0000	0.1827	117.6381	9.2761	0.0379
	(0.0000)	(0.0769)	(45.9735)	(4.7342)	

Appendix 1 Table B Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

Pre 2001	ALPHA	DELTA	ETA	MU	PIN
WORK	0.3001	0.6668	29.1166	47.8683	0.1979
	(0.1871)	(0.3518)	(3.2907)	(5.4052)	
YHOO	1.0000	0.0978	113.4079	6.7760	0.0290
	(0.0000)	(0.1112)	(43.9192)	(5.3042)	
ZIGO	0.0000	1.0000	376.4000	0.0000	0.0000
	(0.0000)	(0.0000)	(49.2981)	(0.0000)	

Appendix 1 Table C: The Probability of Informed Trading (PIN) for Nasdaq Companies During 2001 Post-Decimalization Period

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

Post 2001	ALPHA	DELTA	ETA	MU	PIN
ADSK	0.3000	0.0000	467.3530	316.9806	0.0923
	(0.1732)	(0.0000)	(22.4437)	(84.7785)	
ALKS	1.0000	0.2879	450.1589	186.9922	0.1720
	(0.0000)	(0.1433)	(51.6590)	(29.8284)	
ALXN	0.0000	0.0000	208.6693	87.1819	0.0000
	(0.0000)	(0.0000)	(29.3798)	(1.69E+10)	
AMAT	1.0000	0.0701	106.9772	3.3338	0.0153
	(0.0000)	(0.3515)	(41.5401)	(2.4211)	
AMKR	1.0000	0.4988	575.8064	139.7395	0.1082
	(0.0000)	(0.1694)	(82.5930)	(37.1790)	
ANAD	1.0000	0.1909	308.5375	168.3300	0.2143
	(0.0000)	(0.0887)	(83.4037)	(37.7841)	
ANSR	0.9792	1.0000	78.5963	38.6781	0.1942
	(0.0350)	(0.0000)	(16.3748)	(50.3414)	
APAC	0.3985	0.4913	29.4774	30.9787	0.1731
	(0.1921)	(0.3428)	(4.5558)	(7.0814)	
APLX	0.3096	0.6780	14.5453	22.6403	0.1942
	(0.1748)	(0.3390)	(3.1326)	(3.2161)	
ASCA	0.6048	0.4932	17.4927	16.7248	0.2243
	(0.1813)	(0.2757)	(3.9432)	(4.0985)	
ASFC	1.0000	0.3615	253.9567	107.2382	0.1743
	(0.0000)	(0.1558)	(33.3772)	(26.3207)	
ATGI	0.6955	0.5827	16.4698	20.3611	0.3006
	(0.1770)	(0.2475)	(3.0666)	(4.4082)	
AULT	0.3346	0.4012	8.0936	23.6516	0.3283
	(0.4041)	(1.0319)	(4.0225)	(17.3211)	
AVTR	0.7256	0.2943	7.7867	12.4404	0.3669
	(0.1993)	(0.2510)	(1.7344)	(4.1040)	
BAMM	0.4994	0.7990	16.9434	33.2633	0.3290
	(0.2046)	(0.2313)	(2.7130)	(8.3631)	
BBBY	1.0000	0.5000	1768.7880	432.4111	0.1089
	(0.0000)	(0.1793)	(152.1254)	(78.8687)	
BITS	0.1975	1.0000	10.5752	22.0257	0.1706
	(0.1486)	(0.0000)	(1.9469)	(7.5154)	
BKUN	0.4017	0.4965	61.5329	77.9950	0.2029
	(0.1969)	(0.3302)	(12.5080)	(25.2348)	
BSTE	1.0000	0.0000	230.7818	143.3836	0.2370
	(0.0000)	(0.0000)	(45.8694)	(30.0622)	
BTRN	0.2000	0.0000	44.0000	163.0000	0.2703
	(0.1512)	(0.0000)	(14.3538)	(14.0633)	
BVAS	0.4118	0.7548	10.6996	13.6024	0.2074
	(0.2082)	(0.2823)	(1.3707)	(3.0677)	
CAND	0.2000	0.5000	48.8333	101.1667	0.1716
	(0.1633)	(0.4564)	(12.1054)	(31.5915)	

Appendix 1 Table C Continued

$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$

Post 2001	ALPHA	DELTA	ETA	MU	PIN
CBUK	0.4860	0.0000	32.8545	38.6618	0.2224
	(0.2288)	(0.0000)	(5.7503)	(10.6652)	
CELL	0.9465	1.0000	191.1265	92.3103	0.1860
	(0.0318)	(0.0000)	(22.1683)	(43.3506)	
CENT	0.8090	0.0000	41.6987	30.9057	0.2307
	(0.1511)	(0.0000)	(3.7424)	(3.6181)	
CHIR	1.0000	0.6652	2015.0522	647.3592	0.1384
	(0.0000)	(0.1331)	(112.8088)	(84.5647)	
COMS	1.0000	1.0000	445.2114	180.9754	0.1689
	(0.3706)	(0.0000)	(139.0836)	(62.4765)	
CSCO	0.1205	0.0874	103.7132	2.0694	0.0012
	(0.0492)	(0.3726)	(45.1748)	(3.6179)	
DAVX	0.5000	0.7999	47.2003	51.9953	0.2159
	(0.2041)	(0.2311)	(5.3647)	(8.6558)	
DIAN	0.3000	0.0000	95.1765	159.8235	0.2012
	(0.1732)	(0.0000)	(19.9804)	(30.5053)	
DRTE	0.3000	0.3333	224.8238	160.8438	0.0969
	(0.1871)	(0.3513)	(22.6053)	(52.8548)	
DRYR	0.0000	0.0000	87.2164	35.4914	0.0000
	(0.0000)	(0.0000)	(18.3399)	(11.4127)	
DSTM	1.0000	0.7895	25.8299	17.6401	0.2545
	(0.0000)	(0.1562)	(3.2301)	(4.4588)	
DTPI	1.0000	1.0000	338.1936	154.6791	0.1861
	(0.0000)	(0.0000)	(58.1692)	(74.5269)	
DUCK	0.7370	0.0000	2.0678	4.1576	0.4256
	(0.2801)	(0.0000)	(0.7921)	(1.4875)	
EMMS	1.0000	0.4567	226.5869	98.0338	0.1779
	(0.0000)	(0.1566)	(34.2236)	(35.8472)	
EXBT	0.2500	0.5000	59.3572	141.1428	0.2291
	(0.2165)	(0.5000)	(13.6496)	(60.9005)	
FSII	0.4001	0.2529	97.0048	60.4679	0.1109
	(0.2000)	(0.2822)	(7.8260)	(8.7838)	
FUTR	0.2168	1.0000	5.1809	13.5494	0.2209
	(0.1697)	(0.0000)	(0.9405)	(3.1427)	
GLFD	0.3000	0.3333	106.6471	91.6862	0.1142
	(0.1871)	(0.3514)	(8.8062)	(25.4130)	
HGSI	1.0000	1.0000	170.8690	36.1577	0.0957
	(0.3706)	(0.0000)	(53.9338)	(27.4981)	
HLYW	0.5000	0.2000	86.9333	183.0667	0.3449
	(0.2041)	(0.2309)	(25.3619)	(31.9844)	
HMSY	0.3025	0.3628	20.7648	29.6578	0.1776
	(0.1853)	(0.3852)	(4.6865)	(4.8278)	
HOFF	0.3000	0.0000	140.6471	163.6863	0.1486
	(0.1732)	(0.0000)	(16.7781)	(47.8834)	
HRLY	0.4996	0.2002	14.7385	36.8757	0.3846
	(0.2020)	(0.2309)	(5.0291)	(10.3374)	
HUBG	0.6000	0.1667	12.5006	47.0009	0.5301
	(0.1998)	(0.1965)	(4.5994)	(11.5853)	
INSP	1.0000	0.3743	158.0171	32.1224	0.0923
	(0.0000)	(0.1979)	(62.0124)	(15.5134)	

Appendix 1 Table C Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

Post 2001	ALPHA	DELTA	ETA	MU	PIN
INTC	1.0000	0.1821	111.2567	4.6658	0.0205
	(0.0000)	(0.0950)	(42.6302)	(3.2950)	
ITIG	0.2001	0.0000	20.6656	51.8141	0.2006
	(0.1510)	(0.0000)	(4.0784)	(4.4233)	
LARS	0.2988	1.0000	21.0151	38.3887	0.2144
	(0.1692)	(0.0000)	(5.9058)	(12.0207)	
LNCB	0.3001	0.3332	3.7057	18.9554	0.4342
	(0.1871)	(0.3512)	(1.4933)	(3.2332)	
LTRE	0.4005	0.2510	149.9264	92.0007	0.1094
	(0.1995)	(0.2822)	(9.3733)	(17.9557)	
LUFK	0.5937	0.1685	8.2595	18.6650	0.4015
	(0.1913)	(0.2043)	(2.4940)	(4.1192)	
MDEA	0.4000	0.2517	64.2527	58.7371	0.1546
	(0.2000)	(0.2811)	(9.7482)	(11.2281)	
MEDI	1.0000	1.0000	366.1239	130.7191	0.1515
	(0.3706)	(0.0000)	(118.4689)	(54.9984)	
MEDX	0.20055	(0.00000)	1020.5337	743.5238	0.0681
	(0.13857)	(0.0000)	(2.7956E+06)	(4.4376E+07)	
MINI	0.6460	0.0000	61.8451	35.0799	0.1548
	(0.1678)	(0.0000)	(7.8869)	(16.9913)	
MSFT	0.0000	0.0574	108.2032	4.3848	0.0000
	(0.0000)	(0.0426)	(44.6969)	(3.0230)	
NATR	0.5581	0.4889	12.3199	13.9055	0.2395
	(0.1879)	(0.3168)	(1.6027)	(4.3905)	
NEOG	0.3002	0.6668	57.6449	70.9972	0.1560
	(0.1869)	(0.3525)	(6.4703)	(17.4735)	
NETM	0.4000	0.0000	53.8154	62.3759	0.1882
	(0.1851)	(0.0000)	(8.7116)	(12.1880)	
NTAP	1.0000	0.0886	117.3437	9.5994	0.0393
	(0.0000)	(0.0735)	(46.8339)	(4.7655)	
ODET	0.4000	0.5000	30.6875	59.3123	0.2788
	(0.2000)	(0.3228)	(6.4395)	(10.2348)	
OPTI	0.6961	0.7069	11.8163	22.7955	0.4017
	(0.1800)	(0.2290)	(3.2538)	(5.5209)	
ORCL	0.0000	0.1445	103.7064	2.3710	0.0000
	(0.0000)	(0.1249)	(46.1934)	(4.1771)	
OSIP	0.5000	0.4000	389.1333	303.0667	0.1630
	(0.2041)	(0.2828)	(38.3755)	(57.7238)	
PCCC	0.1000	0.0000	139.7368	244.2632	0.0804
	(0.1134)	(0.0000)	(11.3389)	(11.3389)	
PCDI	0.3010	0.6710	2.8275	13.1084	0.4109
	(0.1846)	(0.3580)	(0.8683)	(4.0046)	
PENX	0.2912	0.6566	9.3605	24.6525	0.2772
	(0.1807)	(0.4570)	(4.0194)	(11.9402)	
PETM	0.4000	0.5000	188.0000	313.2500	0.2500
	(0.2000)	(0.3227)	(41.1375)	(137.6548)	
PLFE	0.5943	0.0000	50.6712	37.7873	0.1814
	(0.1789)	(0.0000)	(5.0263)	(10.3764)	
PRST	0.4000	0.2500	146.6876	124.3126	0.1449
	(0.2000)	(0.2795)	(17.0162)	(23.9910)	

Appendix 1 Table C Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

Post 2001	ALPHA	DELTA	ETA	MU	PIN
PSFT	1.0000	0.4609	134.4481	17.7255	0.0618
	(0.0000)	(0.1872)	(53.0456)	(7.0322)	
PTEN	1.0000	0.0000	604.1765	411.0975	0.2539
	(0.0000)	(0.0000)	(36.7018)	(209.7755)	
QADI	0.3864	0.4653	17.7822	22.6053	0.1972
	(0.1789)	(0.3357)	(4.1145)	(8.4619)	
QDIN	0.3141	1.0000	4.4594	9.1715	0.2442
	(0.1717)	(0.0000)	(1.2829)	(1.0770)	
RCCC	0.5973	0.1629	61.7804	60.6716	0.2268
	(0.1865)	(0.2116)	(12.2040)	(14.0884)	
REMC	0.6124	0.5102	295.1292	150.4479	0.1350
	(0.2688)	(0.3930)	(44.2190)	(64.8967)	
RGBK	0.0148	1.0000	0.8484	1.0310	0.0089
	(0.0056)	(0.0000)	(0.3180)	(0.4229)	
RICK	0.3270	1.0000	2.1887	5.7263	0.2996
	(0.2075)	(0.0000)	(0.6080)	(1.7052)	
SANM	1.0000	0.2832	139.4719	20.1995	0.0675
	(0.0000)	(0.1673)	(53.1691)	(11.3941)	
SCFS	0.4270	0.7605	27.0206	33.8599	0.2111
	(0.2164)	(0.2909)	(4.5979)	(12.1071)	
SCSC	0.5076	0.1970	59.0805	65.2824	0.2190
	(0.1846)	(0.2463)	(11.2819)	(13.8814)	
SMXC	0.2260	0.5390	4.9977	15.7545	0.2626
	(0.1821)	(0.4902)	(1.9372)	(2.4838)	
SNAP	0.3436	1.0000	5.4837	6.7890	0.1754
	(0.2102)	(0.0000)	(1.0720)	(1.9758)	
SOTR	1.0000	0.4000	517.4059	288.3037	0.2179
	(0.0000)	(0.1789)	(78.4556)	(40.9961)	
SPLN	0.5001	0.5996	42.4673	48.7216	0.2229
	(0.2035)	(0.2826)	(6.9447)	(8.5336)	
TACT	0.4770	0.5707	5.0433	11.1385	0.3450
	(0.1872)	(0.3122)	(1.3725)	(2.2520)	
TACX	1.0000	0.5383	1.3309	2.1954	0.4520
	(0.0000)	(0.3210)	(0.4656)	(1.0792)	
TECU	0.0483	0.6102	182.9353	145.8024	0.0189
	(0.0311)	(0.2727)	(16.5401)	(31.6192)	
THRD	1.0000	0.5168	0.5590	1.7154	0.6054
	(0.0000)	(0.3895)	(0.3964)	(1.1503)	
TOPP	0.3000	0.6667	119.0588	118.6078	0.1300
	(0.1871)	(0.3514)	(8.4248)	(9.7580)	
TRAC	0.5997	0.8332	149.0174	144.3536	0.2251
	(0.1982)	(0.1966)	(22.0407)	(48.2555)	
TWMC	0.6001	0.3370	62.5768	73.2363	0.2599
	(0.1999)	(0.2514)	(9.1299)	(11.6591)	
VTSS	1.0000	0.0000	124.8097	13.1562	0.0501
	(0.0000)	(0.0000)	(44.7725)	(5.6532)	
VNWK	0.5990	0.0000	113.4688	114.1267	0.2315
	(0.1803)	0.0000	(13.1908)	(25.0126)	
WCOM	0.9543	0.5334	119.4524	10.6654	0.0409
	(0.3896)	(0.2083)	(49.6205)	(5.6617)	

Appendix 1 Table C Continued

$$PIN = \frac{\mu(1 - P_n(t))}{2\varepsilon + \mu(1 - P_n(t))}$$

Post 2001	ALPHA	DELTA	ETA	MU	PIN
WORK	0.5086	0.5105	32.7782	44.1318	0.2550
	(0.1835)	(0.4346)	(9.1217)	(11.1622)	
YHOO	1.0000	0.3385	129.6868	15.7786	0.0573
	(0.0000)	(0.1714)	(50.1530)	(6.7756)	
ZIGO	1.0000	0.0438	535.4983	257.7645	0.1940
	(0.0000)	(0.0521)	(68.2095)	(80.0687)	

Appendix 1 Table D: The Probability of Informed Trading (PIN) for Nasdaq Companies During 2002 Period

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

2002	ALPHA	DELTA	ETA	MU	PIN
ADSK	1.0000	1.0000	552.2689	253.4983	0.1867
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	
ALKS	1.0000	0.5000	669.7256	184.3984	0.1210
	(0.0000)	(0.1700)	(81.0377)	(31.8086)	
ALXN	1.0000	0.5951	147.0717	75.1244	0.2034
	(0.0000)	(0.1595)	(28.4268)	(28.6018)	
AMAT	1.0000	0.0000	117.4217	7.6820	0.0317
	(0.0000)	(0.0000)	(41.6922)	(3.6923)	
AMKR	1.0000	1.0000	84.8669	75.5934	0.3081
	(0.0000)	(0.0000)	(29.0620)	(23.9024)	
ANAD	0.9999	0.0000	429.7646	161.6171	0.1583
	(0.0001)	(0.0000)	(27.2913)	(36.3784)	
ANSR	0.2996	0.6842	123.7406	86.8536	0.0951
	(0.1855)	(0.3554)	(10.8438)	(28.7729)	
APAC	0.3026	0.3305	39.7885	60.8885	0.1880
	(0.1875)	(0.3369)	(5.5426)	(22.6181)	
APLX	0.2000	0.0000	17.7778	65.2222	0.2684
	(0.1512)	(0.0000)	(2.2153)	(10.7859)	
ASCA	1.0000	1.0000	250.3340	134.8621	0.2122
	(0.0000)	(0.0000)	(40.0436)	(95.9977)	
ASFC	1.0000	0.1634	482.8019	189.7343	0.1642
	(0.0000)	(0.0877)	(61.6800)	(35.8395)	
ATGI	0.5682	1.0000	3.2675	5.9221	0.3399
	(0.2378)	(0.0000)	(0.6293)	(1.8920)	
AULT	0.1250	1.0000	5.6000	32.4000	0.2656
	(0.1479)	(0.0000)	(2.9360)	(2.9359)	
AVTR	0.6980	0.2090	6.4260	14.5384	0.4412
	(0.2874)	(0.2849)	(2.1569)	(7.8410)	
BAMM	0.4006	1.0000	16.3096	29.4058	0.2653
	(0.1853)	(0.0000)	(3.3947)	(3.5507)	
BBBY	1.0000	0.9996	557.8722	236.3342	0.1748
	(0.0000)	(0.0002)	(171.2027)	(69.4436)	
BITS	0.2992	1.0000	9.8326	39.5590	0.3757
	(0.1725)	(0.0000)	(1.5838)	(20.3822)	
BKUN	0.5003	0.0014	201.4998	215.8341	0.2113
	(0.2041)	(0.0012)	(35.8113)	(47.1376)	
BSTE	0.9000	0.7500	444.7199	447.7942	0.3118
	(0.0456)	(0.3062)	(133.8010)	(385.1019)	
BTRN	0.9571	1.0000	0.5779	0.6913	0.3641
	(0.3618)	(0.0000)	(0.2168)	(0.3917)	
BVAS	0.8378	0.6094	19.0638	21.4826	0.3207
	(0.2043)	(0.2493)	(4.9982)	(6.2941)	
CAND	0.2000	0.0000	172.9938	501.5666	0.2248
	(0.1512)	(0.0000)	(43.1427)	(195.0482)	

Appendix 1 Table D Continued

$$PIN = \frac{\mu(1 - P_n(t))}{2\varepsilon + \mu(1 - P_n(t))}$$

2002	ALPHA	DELTA	ETA	MU	PIN
CBUK	0.2999	0.7147	71.8687	110.2558	0.1870
	(0.1856)	(0.4767)	(21.5902)	(46.9737)	
CELL	0.3000	1.0000	122.9421	211.7306	0.2053
	(0.1730)	(0.0000)	(23.2240)	(54.7790)	
CENT	0.4002	0.4593	36.1985	27.2423	0.1309
	(0.1968)	(0.3535)	(4.6201)	(4.1662)	
CHIR	1.0000	1.0000	226.1250	64.4037	0.1247
	(0.3706)	(0.0000)	(74.6145)	(38.1605)	
COMS	0.9571	1.0000	0.5801	0.6942	0.3642
	(0.3618)	(0.0000)	(0.2249)	(0.2797)	
CSCO	1.0000	0.0000	107.6218	4.3464	0.0198
	(0.0000)	(0.0000)	(38.7033)	(1.9749)	
DAVX	0.2999	0.6666	34.6497	62.3554	0.2125
	(0.1866)	(0.3558)	(6.3087)	(26.1495)	
DIAN	1.0000	0.6221	356.1582	163.4474	0.1866
	(0.0000)	(0.1660)	(54.6827)	(41.5392)	
DRTE	0.6066	0.0000	166.6267	82.2987	0.1303
	(0.1597)	(0.0000)	(18.7160)	(27.5529)	
DRYR	0.3000	0.0000	242.1176	189.2157	0.1049
	(0.1732)	(0.0000)	(17.4988)	(23.9896)	
DSTM	0.3999	0.7502	54.2529	70.5055	0.2062
	(0.1996)	(0.2810)	(9.8997)	(21.4827)	
DTPI	0.2962	1.0000	84.5154	43.4512	0.0707
	(0.2688)	(0.0000)	(23.8794)	(51.9337)	
DUCK	0.5877	0.3400	13.0368	18.0819	0.2895
	(0.1992)	(0.2619)	(2.7027)	(2.7631)	
EMMS	0.3242	1.0000	713.7750	251.6166	0.0541
	(0.1644)	(0.0000)	(44.3687)	(131.3850)	
EXBT	0.3000	0.6665	27.7062	49.6267	0.2118
	(0.1871)	(0.3514)	(4.8584)	(13.6600)	
FSII	0.0000	0.0000	79.4469	45.8741	0.0000
	(0.0000)	(0.0000)	(16.1933)	(1.56E+09)	
FUTR	0.3141	0.7397	1.8527	3.6669	0.2371
	(0.2901)	(1.0655)	(1.0663)	(2.1787)	
GLFD	0.3000	1.0000	195.5294	222.4706	0.1458
	(0.1732)	(0.0000)	(18.1044)	(51.1818)	
HGSI	1.0000	1.0000	735.9428	312.6643	0.1752
	(0.0000)	(0.0000)	(192.4401)	(59.3083)	
HLYW	1.0000	1.0000	559.1039	266.3812	0.1924
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	
HMSY	0.3997	1.0000	27.1927	70.0808	0.3400
	(0.1843)	(0.0000)	(5.5930)	(28.1809)	
HOFF	1.0000	0.6373	195.5990	113.2643	0.2245
	(0.0000)	(0.1474)	(47.3491)	(25.6472)	
HRLY	1.0000	0.4058381	409.46784	300.22659	0.2683
	(0.0000)	(0.2447)	(88.8599)	(215.8947)	
HUBG	0.1395	0.0000	1.7757	9.4869	0.2715
	(0.1559)	(0.0000)	(0.5422)	(1.1365)	
INSP	0.5000	0.8000	415.0666	306.3328	0.1558
	(0.2041)	(0.2309)	(50.7023)	(61.2927)	

Appendix 1 Table D Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

2002	ALPHA	DELTA	ETA	MU	PIN
INTC	1.0000	1.0000	112.7756	6.6743	0.0287
	(0.3706)	(0.0000)	(32.5298)	(19.5114)	
ITIG	0.6735	0.5593	10.6976	12.0345	0.2747
	(0.1445)	(0.2719)	(3.3156)	(3.5993)	
LARS	0.2219	0.0000	2.5034	15.9960	0.4148
	(0.1692)	(0.0000)	(0.8337)	(6.4622)	
LNCB	1.0000	1.0000	1.6667	1.2222	0.2683
	(0.0000)	(0.0000)	(0.4364)	(0.6849)	
LTRE	0.2995	0.6658	82.3683	76.3506	0.1219
	(0.1858)	(0.3506)	(11.5039)	(27.8383)	
LUFK	0.3710	0.0000	24.7420	45.5910	0.2548
	(0.6231)	(0.0000)	(14.9002)	(43.6514)	
MDEA	0.0000	0.5555	14.2969	8.3662	0.0000
	(0.0000)	(1.7490)	(5.0631)	(2.3195)	
MEDI	1.0000	0.0282	230.4912	78.8840	0.1461
	(0.0000)	(0.0169)	(82.3993)	(27.2007)	
MEDX	1.0000	0.7632	848.0486	318.2348	0.1580
	(0.0000)	(0.1298)	(103.2735)	(66.4630)	
MINI	0.2000	0.5000	218.2778	487.2222	0.1825
	(0.1633)	(0.4564)	(53.2101)	(139.1274)	
MSFT	1.0000	0.0000	110.2019	5.5793	0.0247
	(0.0000)	(0.0000)	(38.9788)	(2.7355)	
NATR	0.5011	0.2156	39.3360	42.9578	0.2148
	(0.2007)	(0.2406)	(5.2928)	(11.9500)	
NEOG	0.1001	0.0000	12.8417	30.1374	0.1051
	(0.1135)	(0.0000)	(1.7383)	(1.7297)	
NETM	0.4004	0.7482	42.3110	53.8911	0.2032
	(0.1957)	(0.2813)	(8.1020)	(11.8018)	
NTAP	1.0000	1.0000	146.4472	23.9323	0.0755
	(0.3706)	(0.0000)	(46.4998)	(25.5735)	
ODET	(0.0000)	0.6036	17.5500	0.0000	0.0000
	(0.0000)	(0.0000)	(2.7174)	(0.0000)	
OPTI	0.2222	1.0000	4.6875	30.8125	0.4221
	(0.1697)	(0.0000)	(2.3483)	(4.9921)	
ORCL	0.5444	0.5318	108.1337	3.9879	0.0099
	(0.2222)	(0.2111)	(48.3571)	(3.0252)	
OSIP	1.0000	1.0000	941.77299	692.68301	0.2689
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	
PCCC	0.3001	0.6668	52.8809	88.4373	0.2006
	(0.1870)	(0.3524)	(5.1067)	(29.6795)	
PCDI	0.3297	0.8152	2.2499	5.3085	0.2800
	(0.5364)	(1.3417)	(1.6022)	(3.1964)	
PENX	0.1997	0.5007	10.6701	44.8640	0.2957
	(0.1623)	(0.4642)	(2.2338)	(21.6817)	
PETM	1.0000	0.3302	421.5275	183.8503	0.1790
	(0.0000)	(0.1861)	(84.3570)	(69.7392)	
PLFE	0.5704	0.4590	94.7539	60.4683	0.1540
	(0.2351)	(0.2766)	(13.2217)	(8.7534)	
PRST	0.5348	0.4395	67.1802	59.7272	0.1921
	(0.3554)	(0.5434)	(12.1362)	(23.6601)	

Appendix 1 Table D Continued

$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$

2002	ALPHA	DELTA	ETA	MU	PIN
PSFT	1.0000	0.7473	151.7784	26.1910	0.0794
	(0.0000)	(0.1175)	(57.2220)	(11.8172)	
PTEN	1.0000	0.2153	924.9050	184.1536	0.0905
	(0.0000)	(0.1577)	(65.5248)	(32.9326)	
QADI	0.4940	0.7976	19.2712	28.8602	0.2700
	(0.2007)	(0.2327)	(2.8993)	(9.1431)	
QDIN	1.0000	0.4906	5.1396	7.8209	0.4321
	(0.0000)	(0.1939)	(1.5005)	(1.5868)	
RCCC	0.2952	0.4228	70.8317	76.3501	0.1373
	(0.1719)	(0.4359)	(11.3603)	(28.1364)	
REMC	0.3974	0.5032	154.3415	103.7104	0.1178
	(0.1920)	(0.3396)	(17.8436)	(17.0216)	
RGBK	1.0000	0.5544	730.1268	231.7128	0.1369
	(0.0000)	(0.1598)	(58.4693)	(41.9857)	
RICK	0.1250	1.0000	3.4000	27.6000	0.3366
	(0.1479)	(0.0000)	(0.9886)	(0.9886)	
SANM	1.0000	0.0000	192.8697	50.1703	0.1151
	(0.0000)	(0.0000)	(71.0577)	(19.5006)	
SCFS	0.4912	0.4003	149.8041	67.3632	0.0995
	(0.2036)	(0.3306)	(17.2885)	(18.0512)	
SCSC	0.4000	0.4765	65.7677	78.6616	0.1930
	(0.2000)	(0.3307)	(11.2660)	(13.3864)	
SMXC	0.0000	0.5801	4.2222	(0.0000)	0.0000
	(0.0000)	(0.0000)	(1.3455)	(0.0000)	
SNAP	0.8154	1.0000	3.8214	10.8625	0.5368
	(0.1622)	(0.0000)	(1.0303)	(1.1049)	
SOTR	1.0000	0.2280	1174.7056	270.9270	0.1034
	(0.0000)	(0.1588)	(82.4915)	(67.3173)	
SPLN	0.4114	0.8476	22.1812	20.0240	0.1566
	(0.1978)	(0.3890)	(2.6416)	(5.5249)	
TACT	0.4955	0.7918	8.3059	19.3520	0.3660
	(0.1938)	(0.2381)	(2.4637)	(5.0509)	
TACX	0.4421	0.0000	6.4482	11.7962	0.2879
	(0.1994)	(0.0000)	(1.6753)	(2.1873)	
TECU	0.9560	0.2056	326.0010	268.6629	0.2826
	(0.0283)	(0.1762)	(77.2545)	(73.7870)	
THRD	1.0000	1.0000	1.0000	2.0000	0.5000
	(0.0000)	(0.0000)	(0.7303)	(0.5164)	
TOPP	0.0000	0.0000	90.7549	46.5184	0.0000
	(0.0000)	(0.0000)	(16.1988)	(25.2919)	
TRAC	0.5450	1.0000	19.7759	29.8111	0.2912
	(0.2584)	(0.0000)	(3.0856)	(9.1199)	
TWMC	0.4989	0.3757	37.9099	50.4694	0.2493
	(0.1982)	(0.2963)	(10.1690)	(12.7115)	
VTSS	1.0000	1.0000	244.2528	74.1996	0.1319
	(0.3706)	(0.0000)	(80.7381)	(39.6966)	
VNWK	0.1971	0.0001	214.7380	212.1127	0.0887
	(0.1615)	(0.0001)	(27.2365)	(50.6203)	
WCOM	0.0000	0.0099	103.4418	2.3174	0.0000
	(0.0000)	(0.0064)	(44.8436)	(4.6439)	

Appendix 1 Table D Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

2002	ALPHA	DELTA	ETA	MU	PIN
WORK	0.1999	1.0000	65.5620	315.5344	0.3248
	(0.1474)	(0.0000)	(27.0957)	(167.8532)	
YHOO	1.0000	1.0000	136.0990	18.8413	0.0647
	(0.3706)	(0.0000)	(42.0050)	(23.9200)	
ZIGO	0.4000	1.0000	81.7499	108.7494	0.2101
	(0.1852)	(0.0000)	(15.1466)	(21.6293)	

Appendix 1 Table E: The Probability of Informed Trading (PIN) for NYSE Companies During 1999 Period

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

1999	ALPHA	DELTA	ETA	MU	PIN
AC	0.5116	0.3422	81.7082	'31.4387	0.0896
	(0.2926)	(0.3011)	(9.1968)	(8.7100)	
AGE	0.3457	0.6706	251.1008	72.0302	0.0472
	(0.2039)	(0.5402)	(20.7739)	(25.1033)	
AHG	0.1000	1.0000	72.7368	114.2631	0.0728
	(0.1134)	(0.0000)	(6.1790)	(6.1790)	
AK	0.4907	0.2586	11.3006	7.1295	0.1341
	(0.2638)	(0.3483)	(1.7268)	(2.4336)	
ALZ	0.7179	1.0000	5.2652	2.3256	0.1368
	(0.5506)	(0.0000)	(1.0680)	(1.4516)	
AMN	0.2939	0.0000	11.7093	21.0329	0.2088
	(0.1940)	(0.0000)	(2.1683)	(9.6011)	
AMU	0.5315	0.8335	4.0944	5.1008	0.2487
	(0.3159)	(0.4526)	(1.3583)	(1.5611)	
APA	0.5000	0.2000	351.2000	300.2000	0.1761
	(0.2041)	(0.2309)	(47.5952)	(61.6953)	
APX	0.1811	0.0000	9.4424	7.2610	0.0651
	(0.2059)	(0.0000)	(1.2081)	(4.3797)	
ATS	0.4382	0.0000	8.6350	7.8279	0.1657
	(0.2111)	(0.0000)	(1.0545)	(2.3288)	
BA	0.4020	0.7497	1490.7073	742.9360	0.0910
	(13.0908)	(13.1237)	(3.93E+06)	(2.67E+07)	
BAC	1.0000	0.9922	1498.2473	740.2734	0.1981
	(0.0000)	(0.0000)	(192.5967)	(0.0000)	
BAX	1.0000	0.5895	378.7340	113.8755	0.1307
	(0.0000)	(0.1800)	(25.5331)	(23.7025)	
BKH	0.5991	0.5990	31.3078	27.3482	0.2074
	(0.1969)	(0.2843)	(4.9113)	(5.8930)	
BLX	0.4000	0.0000	22.8751	33.3721	0.2259
	(0.1851)	(0.0000)	(4.6691)	(5.4977)	
BMT	0.7133	0.3951	10.5287	8.6116	0.2258
	(0.2101)	(0.2692)	(1.6382)	(1.9852)	
BNO	0.5586	0.5194	31.1085	26.4626	0.1920
	(0.3565)	(0.2853)	(5.6787)	(6.9605)	
BQT	0.8525	0.0000	14.9363	10.2379	0.2261
	(0.3357)	(0.0000)	(1.5557)	(3.5078)	
C	0.6000	0.3332	2504.0015	617.8283	0.0689
	(0.2000)	(0.2484)	(127.8835)	(132.8099)	
CBA	0.6936	0.8739	6.5001	7.9290	0.2973
	(0.1733)	(0.1843)	(1.7091)	(1.7699)	
CD	0.2472	0.0000	1320.3035	578.5650	0.0514
	(0.1435)	(0.0000)	(118.9172)	(181.3693)	
CNE	0.5674	0.2010	15.5365	12.2091	0.1823
	(0.1993)	(0.2366)	(2.1758)	(4.1080)	

Appendix 1 Table E Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

1999	ALPHA	DELTA	ETA	MU	PIN
COE	0.5337	0.6178	15.1040	12.5379	0.1814
	(0.1476)	(0.3360)	(2.3617)	(3.8827)	
COO	0.1000	0.0000	104.7895	155.2105	0.0689
	(0.1134)	(0.0000)	(9.2298)	(9.2298)	
DEL	0.4240	0.0000	20.4539	12.4812	0.1146
	(0.1557)	(0.0000)	(2.7846)	(3.5730)	
DIS	1.0000	1.0000	409.8678	170.1742	0.1719
	(0.3706)	(0.0000)	(62.1220)	(9.7509)	
DOL	0.3000	0.0000	122.7057	98.9587	0.1079
	(0.1732)	(0.0000)	(11.1420)	(11.0291)	
DY	0.2000	1.0000	104.7222	121.7778	0.1042
	(0.1512)	(0.0000)	(12.5181)	(29.7586)	
E	0.8924	0.1076	45.5145	32.0174	0.2389
	(0.1355)	(0.1352)	(5.1230)	(5.3906)	
EGP	1.0000	1.0000	19.9000	11.7000	0.2272
	(0.0000)	(0.0000)	(1.9650)	(2.2751)	
EL	0.3968	0.2523	145.9874	106.6579	0.1266
	(0.1869)	(0.2790)	(20.8309)	(41.5672)	
ESF	0.4961	1.0000	50.4826	48.2470	0.1916
	(0.1903)	(0.0000)	(5.0500)	(9.9983)	
ETN	0.4958	0.0000	281.7570	215.7924	0.1596
	(0.1771)	(0.0000)	(36.4070)	(66.6990)	
ETT	0.2999	0.0000	36.1192	68.5555	0.2216
	(0.1727)	(0.0000)	(9.2610)	(25.0960)	
FCF	0.5251	0.1899	16.7450	18.4914	0.2248
	(0.1993)	(0.2266)	(2.9839)	(3.4795)	
FOE	0.6094	0.0000	57.5685	25.5385	0.1191
	(0.2233)	(0.0000)	(6.8814)	(7.1608)	
FRT	0.6171	0.0000	58.9640	36.3946	0.1600
	(0.1563)	(0.0000)	(5.2217)	(7.8266)	
FTS	0.3000	0.3333	46.3529	73.3137	0.1918
	(0.1871)	(0.3514)	(5.6355)	(13.5661)	
GAM	0.2532	1.0000	14.6401	9.9518	0.0792
	(0.2024)	(0.0000)	(1.1713)	(2.8276)	
GFF	0.4060	0.0000	26.1948	9.8791	0.0711
	(0.3580)	(0.0000)	(2.4996)	(5.8748)	
GLW	0.2000	0.0000	344.7778	209.7222	0.0573
	(0.1512)	(0.0000)	(23.3295)	(23.6400)	
GRB	0.1000	1.0000	36.7368	45.2587	0.0580
	(0.1134)	(0.0000)	(3.7212)	(3.7180)	
GVA	0.3084	0.2660	61.6983	54.4859	0.1199
	(0.1739)	(0.3859)	(8.3336)	(13.0386)	
HMX	0.4451	0.5315	30.2244	17.6412	0.1150
	(0.1783)	(0.3657)	(3.9226)	(4.5188)	
IMT	0.1820	1.0000	11.7188	2.5408	0.0194
	(0.6250)	(0.0000)	(1.3969)	(3.6804)	
ION	0.5279	0.6110	35.1314	25.0756	0.1585
	(0.1922)	(0.2968)	(5.0229)	(5.6724)	
IPP	0.3607	1.0000	23.3697	19.8543	0.1329
	(0.1702)	(0.0000)	(2.0534)	(6.6631)	

Appendix 1 Table E Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

1999	ALPHA	DELTA	ETA	MU	PIN
IQM	0.2630	1.0000	7.1485	9.5185	0.1490
	(0.1630)	(0.0000)	(0.8404)	(1.9643)	
JP	0.9000	0.0000	210.1825	94.5957	0.1684
	(0.1134)	(0.0000)	(19.2753)	(20.6617)	
KSS	0.5592	0.7230	424.3813	79.2844	0.0496
	(0.2446)	(0.2732)	(20.8926)	(22.1358)	
LDG	0.4154	0.0000	138.6084	49.5451	0.0691
	(0.1797)	(0.0000)	(7.7440)	(6.5699)	
LFG	0.4182	0.6171	40.1485	21.0476	0.0988
	(0.1657)	(0.3542)	(4.2097)	(4.5750)	
LU	1.0000	0.0000	176.2167	39.9987	0.1019
	(0.0000)	(0.0000)	(60.8746)	(15.5303)	
MDA	0.2996	0.0000	37.2483	36.7248	0.1287
	(0.1721)	(0.0000)	(4.0129)	(9.6555)	
MHK	0.5910	0.0000	52.9016	53.4633	0.2300
	(0.2030)	(0.0000)	(7.7704)	(12.6653)	
MHO	0.3555	0.2857	4.6858	13.8640	0.3446
	(0.1784)	(0.3720)	(1.3933)	(5.5178)	
MIL	0.3010	0.6697	159.6271	100.4719	0.0865
	(0.1856)	(0.3580)	(15.8567)	(17.8634)	
MM	0.4926	0.6090	48.4664	47.4367	0.1942
	(0.1899)	(0.3263)	(6.7854)	(9.2709)	
MO	1.0000	1.0000	351.7819	133.2374	0.1592
	(0.3706)	(0.0000)	(122.5768)	(56.7361)	
MU	1.0000	0.0014	1557.0777	745.1331	0.1931
	(0.0000)	(0.0001)	(146.7070)	(0.0110)	
MUO	0.6993	0.7133	7.2410	16.1852	0.4387
	(0.1876)	(0.2209)	(1.5346)	(3.5448)	
NGI	0.3617	1.0000	5.6456	10.2529	0.2472
	(0.2553)	(0.0000)	(1.0936)	(3.4411)	
NR	0.6560	0.0000	57.8405	21.6759	0.1095
	(0.1658)	(0.0000)	(4.0861)	(5.5688)	
NUC	0.3503	0.0000	10.3504	9.4175	0.1375
	(0.2007)	(0.0000)	(0.9854)	(1.7188)	
PAI	1.0000	0.3645	4.3229	5.7542	0.3996
	(0.0000)	(0.2052)	(0.8620)	(1.6051)	
PCG	0.4044	1.0000	243.8400	142.4771	0.1057
	(0.1826)	(0.0000)	(14.4151)	(31.8950)	
PEI	1.0000	0.1321	20.1738	10.8523	0.2120
	(0.0000)	(0.1549)	(2.1625)	(3.0978)	
PIM	0.5654	1.0000	43.9507	21.7512	0.1227
	(0.1905)	(0.0000)	(3.0299)	(4.7713)	
PKE	0.3715	1.0000	35.9248	20.0573	0.0940
	(0.1761)	(0.0000)	(3.1509)	(5.2205)	
PNM	0.3989	0.0000	57.1168	33.5108	0.1048
	(0.1808)	(0.0000)	(5.9245)	(7.4201)	
POS	0.4800	0.2648	99.0847	56.7256	0.1208
	(0.1368)	(0.3116)	(16.1247)	(12.2187)	
PPL	0.3173	0.6737	196.5225	65.0862	0.0499
	(0.1822)	(0.3613)	(8.0513)	(10.2068)	

Appendix 1 Table E Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

1999	ALPHA	DELTA	ETA	MU	PIN
PPM	0.8124	0.1620	5.2612	4.1573	0.2430
	(0.3665)	(0.2190)	(1.3959)	(1.1177)	
PSA	0.8282	0.9548	64.6770	34.9506	0.1829
	(0.4007)	(0.1428)	(9.6238)	(8.7543)	
PZL	0.6966	0.5693	123.7921	64.1944	0.1530
	(0.1803)	(0.2476)	(12.7864)	(9.7279)	
RI	0.4262	0.2332	54.6019	40.3452	0.1360
	(0.1794)	(0.2598)	(7.6658)	(7.8529)	
RYL	0.2882	0.0000	77.8642	54.3780	0.0914
	(0.1598)	(0.0000)	(6.9369)	(14.2227)	
SBR	0.1000	1.0000	9.7368	32.2626	0.1421
	(0.1134)	(0.0000)	(1.3619)	(1.3618)	
SCL	0.7585	0.1706	7.7164	7.4716	0.2686
	(0.2580)	(0.2141)	(1.1653)	(2.1113)	
SEL	1.0000	0.3444	4.0371	1.7258	0.1761
	(0.0000)	(0.3710)	(1.4402)	(1.9382)	
SKP	1.0000	0.9004	6.1054	9.2892	0.4321
	(0.0000)	(0.1135)	(1.1442)	(1.1154)	
SLB	1.0000	0.1008	691.2763	253.2265	0.1548
	(0.0000)	(0.1028)	(96.0322)	(52.0109)	
STW	0.4276	0.0000	4.8722	8.0811	0.2618
	(0.2020)	(0.0000)	(0.7957)	(2.0674)	
T	1.0000	1.0000	265.2451	89.8589	0.1449
	(0.0000)	(0.0000)	(86.0045)	(30.7979)	
TDP	0.3001	0.6532	52.7790	35.4672	0.0916
	(0.1870)	(0.3618)	(2.9691)	(4.9706)	
TEO	0.2000	1.0000	118.4444	102.0556	0.0793
	(0.1512)	(0.0000)	(12.8686)	(24.8341)	
TLD	0.4843	0.0000	26.6450	19.2247	0.1487
	(0.1687)	(0.0000)	(4.6950)	(4.3363)	
TSM	0.1000	0.0000	139.0000	154.0000	0.0525
	(0.1134)	(0.0000)	(8.9500)	(8.9499)	
TSO	0.1954	0.5124	54.9680	42.8127	0.0707
	(0.1632)	(0.5163)	(5.1305)	(15.3079)	
UCU	0.3654	0.5394	137.0140	35.4990	0.0452
	(0.2162)	(0.5621)	(6.8707)	(13.3003)	
USU	0.7722	0.8912	71.9144	38.4242	0.1710
	(0.2598)	(0.1880)	(10.7619)	(8.1491)	
VCV	1.0000	0.0000	3.9000	0.4000	0.0488
	(0.0000)	(0.0000)	(0.7323)	(0.7937)	
VIM	0.4829	0.7132	3.9787	6.9217	0.2958
	(0.4019)	(0.3362)	(1.0318)	(3.4071)	
VLY	0.1000	0.0000	32.0524	37.9332	0.0559
	(0.1134)	(0.0000)	(1.8836)	(1.8841)	
WES	0.3322	0.3067	8.2170	11.0369	0.1824
	(0.2185)	(0.3627)	(1.5778)	(4.5328)	
WLT	0.5392	0.1377	50.1145	22.5705	0.1083
	(0.3150)	(0.5723)	(10.9867)	(6.6642)	
WNC	0.1002	0.0000	64.6825	62.2538	0.0460
	(0.1135)	(0.0000)	(4.1117)	(4.0602)	

Appendix 1 Table E Continued

$$PIN = \frac{\mu(1 - P_n(t))}{2\varepsilon + \mu(1 - P_n(t))}$$

1999	ALPHA	DELTA	ETA	MU	PIN
WPI	0.2991	0.0000	252.4507	121.0259	0.0669
	(0.1714)	(0.0000)	(16.1854)	(39.9809)	
WRC	0.1000	0.0000	96.6316	109.3678	0.0536
	(0.1134)	(0.0000)	(7.8485)	(7.8468)	
ZAP	0.9329	1.0000	122.2106	47.5732	0.1537
	(0.2046)	(0.0000)	(7.4419)	(9.5503)	

Appendix 1 Table F: The Probability of Informed Trading (PIN) for NYSE Companies During 2001 Pre-Decimalization Period

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

Pre 2001	ALPHA	DELTA	ETA	MU	PIN
AC	0.5000	0.0000	231.8667	177.9333	0.1610
	(0.1890)	(0.0000)	(16.1949)	(21.3624)	
AGE	0.5993	0.0000	496.4919	177.4122	0.0967
	(0.1782)	(0.0000)	(43.0440)	(46.6973)	
AHG	0.4000	0.5000	205.2485	164.4916	0.1382
	(0.1997)	(0.3230)	(33.4964)	(36.9377)	
AK	0.4427	0.0000	44.1603	45.1323	0.1845
	(0.3473)	(0.0000)	(13.8692)	(20.3990)	
ALZ	0.6453	0.3908	9.8480	5.4298	0.1510
	(0.2256)	(0.3891)	(1.9530)	(2.8265)	
AMN	0.5683	0.0622	24.3867	23.9790	0.2184
	(0.1453)	(0.3357)	(8.5291)	(8.3163)	
AMU	0.3971	0.7479	8.7105	14.3026	0.2458
	(0.1966)	(0.2828)	(1.4970)	(1.9387)	
APA	0.7999	0.0000	1079.7676	343.3802	0.1128
	(0.1509)	(0.0000)	(40.1046)	(27.7647)	
APX	0.3589	0.0000	12.2286	8.4777	0.1106
	(0.1847)	(0.0000)	(1.7019)	(2.1992)	
ATS	0.3925	1.0000	10.2223	10.5876	0.1689
	(0.1791)	(0.0000)	(1.6003)	(1.5034)	
BA	1.0000	0.3012	1305.5648	242.2853	0.0849
	(0.0000)	(0.1448)	(145.0710)	(54.9545)	
BAC	1.0000	1.0000	1531.4000	744.9482	0.1956
	0.0000	0.0000	(179.6181)	(1007.9161)	
BAX	1.0000	0.3210	763.1196	262.1440	0.1466
	(0.0000)	(0.1801)	(91.9530)	(48.7022)	
BKH	0.3002	0.0000	166.6443	92.9890	0.0773
	(0.1732)	(0.0000)	(9.2934)	(12.0400)	
BLX	0.4698	0.2407	12.9305	19.8765	0.2653
	(0.1687)	(0.2711)	(3.1482)	(3.5899)	
BMT	0.4269	0.5155	10.0307	4.7760	0.0922
	(0.2099)	(0.6166)	(2.2084)	(3.4228)	
BNO	0.4506	1.0000	32.4897	15.1375	0.0950
	(0.1835)	(0.0000)	(2.6289)	(3.8071)	
BQT	0.2032	0.0000	19.4873	23.2528	0.1081
	(0.1526)	(0.0000)	(1.5285)	(1.9630)	
C	1.0000	1.0000	307.2774	110.6963	0.1526
	(0.0000)	(0.0000)	(98.5745)	(35.8933)	
CBA	0.5798	0.2998	36.3110	25.8325	0.1710
	(0.1704)	(0.2903)	(6.6484)	(6.0527)	
CD	1.0000	0.0000	722.4466	331.1001	0.1864
	(0.0000)	(0.0000)	(73.4501)	(67.2404)	
CNE	0.4825	0.1965	4.2415	3.3516	0.1601
	(0.3112)	(0.5836)	(1.1055)	(2.4340)	

Appendix 1 Table F Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

Pre 2001	ALPHA	DELTA	ETA	MU	PIN
COE	0.2996	0.3269	20.2474	37.4053	0.2167
	(0.1843)	(0.3541)	(3.4667)	(9.9615)	
COO	0.7942	0.1259	87.7616	73.1303	0.2486
	(0.1454)	(0.1530)	(15.0569)	(13.9504)	
DEL	0.7892	0.0000	9.9183	20.4814	0.4490
	(0.1527)	(0.0000)	(1.5515)	(4.2974)	
DIS	0.9999	0.0000	1652.8838	548.8937	0.1424
	(0.0001)	(0.0000)	(80.7132)	(206.5060)	
DOL	0.4027	0.2738	189.4183	93.2763	0.0902
	(0.1924)	(0.3125)	(23.9280)	(29.7308)	
DY	1.0000	0.0000	355.1673	154.5723	0.1787
	(0.0000)	(0.0000)	(82.5752)	(38.0233)	
E	0.4000	0.2056	90.9930	71.0350	0.1350
	(0.2000)	(0.2854)	(8.6716)	(11.2543)	
EGP	0.4973	0.4266	38.0671	30.6960	0.1670
	(0.1971)	(0.2995)	(5.9033)	(6.4576)	
EL	0.7981	0.0000	270.1993	148.5973	0.1800
	(0.1492)	(0.0000)	(19.3434)	(18.8287)	
ESF	0.2001	0.5002	82.7211	96.7607	0.1048
	(0.1632)	(0.4563)	(10.4855)	(13.9173)	
ETN	1.0000	0.8419	371.7169	158.2554	0.1755
	(0.0000)	(0.0614)	(45.1741)	(31.2169)	
ETT	0.5192	1.0000	12.4610	8.2398	0.1465
	(0.1641)	(0.0000)	(1.8774)	(2.0775)	
FCF	0.3209	0.0000	36.0972	25.2552	0.1009
	(0.2040)	(0.0000)	(4.5151)	(7.2310)	
FOE	0.2000	0.5000	130.0555	95.4439	0.0684
	(0.1633)	(0.4564)	(9.0723)	(15.1393)	
FRT	0.5796	0.1876	61.3487	45.0336	0.1754
	(0.2005)	(0.2110)	(8.3653)	(6.8121)	
FTS	0.5000	0.0000	159.6667	123.1334	0.1616
	(0.1890)	(0.0000)	(18.3456)	(31.4803)	
GAM	0.6000	0.0000	40.3859	27.2122	0.1682
	(0.1819)	(0.0000)	(4.7168)	(4.2726)	
GFF	0.2958	0.0000	24.8696	26.5763	0.1365
	(0.1714)	(0.0000)	(3.5011)	(5.9464)	
GLW	1.0000	0.0000	117.5149	10.7917	0.0439
	(0.0000)	(0.0000)	(44.7655)	(12.4974)	
GRB	0.6931	0.0000	32.0455	22.9545	0.1989
	(0.1695)	(0.0000)	(4.3221)	(4.2749)	
GVA	0.2085	0.0000	106.2557	69.5051	0.0638
	(0.1458)	(0.0000)	(8.4085)	(11.8674)	
HMX	0.2098	0.4851	21.0834	21.6061	0.0971
	(0.1662)	(0.4830)	(2.6581)	(4.3347)	
IMT	0.2397	0.5542	9.1823	11.8303	0.1337
	(0.1709)	(0.5122)	(1.4063)	(2.3919)	
ION	0.4004	0.0000	64.9956	60.4651	0.1570
	(0.1849)	(0.0000)	(8.4775)	(10.9172)	
IPP	0.1026	0.0000	34.0822	43.2362	0.0611
	(0.1150)	(0.0000)	(2.9005)	(2.4690)	

Appendix 1 Table F Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

Pre 2001	ALPHA	DELTA	ETA	MU	PIN
IQM	0.4079	0.7361	13.9545	8.0688	0.1055
	(0.2288)	(0.4642)	(2.1288)	(3.0358)	
JP	0.6000	0.1667	491.5721	151.5936	0.0847
	(0.2000)	(0.1965)	(32.4676)	(33.3077)	
KSS	0.4972	0.4972	973.3318	973.3318	0.1991
	(0.1865)	(0.0000)	(35.3883)	(37.2446)	
LDG	0.7753	0.2799	150.4659	41.3599	0.0963
	(0.1377)	(0.2318)	(15.3957)	(14.2065)	
LFG	0.3009	0.6638	150.2728	115.8488	0.1039
	(0.1839)	(0.3764)	(19.2974)	(45.7395)	
LU	1.0000	0.0000	131.7731	17.5421	0.0624
	(0.0000)	(0.0000)	(49.8196)	(9.7467)	
MDA	0.4051	0.5461	15.7457	16.5621	0.1756
	(0.3903)	(0.7579)	(4.5782)	(9.7321)	
MHK	0.4041	0.0000	152.9984	76.2247	0.0915
	(0.1828)	(0.0000)	(11.7255)	(16.9958)	
MHO	0.7935	0.0000	34.2672	33.7319	0.2809
	(0.1435)	(0.0000)	(4.7842)	(7.2057)	
MIL	0.3000	0.3333	679.6473	308.0176	0.0637
	(0.1871)	(0.3514)	(53.3743)	(57.3174)	
MM	0.3162	0.5994	75.8915	57.6083	0.1072
	(0.1896)	(0.6069)	(13.5776)	(21.6462)	
MO	0.5636	0.0000	1536.5900	254.7676	0.0446
	(0.1657)	(0.0000)	(78.6457)	(116.8572)	
MU	1.0000	1.0000	212.6791	58.0845	0.1201
	(0.3706)	(0.0000)	(72.6939)	(42.9921)	
MUO	0.0000	0.0000	6.2000	13.7712	0.0000
	(0.0000)	(0.0000)	(1.3421)	(3.8872)	
NGI	0.2859	1.0000	3.8412	7.4060	0.2161
	(0.2043)	(0.0000)	(0.8764)	(1.9552)	
NR	0.2987	0.0000	93.8199	68.5060	0.0983
	(0.1686)	(0.0000)	(11.3193)	(19.5225)	
NUC	0.1936	0.5163	13.6090	22.6342	0.1387
	(0.1555)	(0.5344)	(2.3466)	(7.4541)	
PAI	1.0000	1.0000	6.9000	1.0000	0.0676
	(0.0000)	(0.0000)	(0.8580)	(1.2041)	
PCG	1.0000	0.0000	1250.6374	703.9746	0.2196
	(0.0000)	(0.0000)	(140.8727)	(99.2887)	
PEI	0.5928	0.0603	31.8089	35.8998	0.2507
	(0.1878)	(0.2067)	(4.7769)	(8.2405)	
PIM	0.6595	0.1539	52.0057	28.0347	0.1509
	(0.2573)	(0.2106)	(6.1380)	(7.3338)	
PKE	0.4993	0.0000	170.7656	124.5070	0.1540
	(0.1831)	(0.0000)	(25.2508)	(28.7907)	
PNM	0.4528	0.2204	142.7306	68.3254	0.0978
	(0.2050)	(0.2856)	(17.6003)	(12.0847)	
POS	0.3000	0.3000	251.2941	251.2941	0.1304
	(0.1732)	(0.0000)	(55.0831)	(186.4614)	
PPL	0.1000	0.0000	576.9474	412.0526	0.0345
	(0.1134)	(0.0000)	(22.3092)	(22.3092)	

Appendix 1 Table F Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

Pre 2001	ALPHA	DELTA	ETA	MU	PIN
PPM	0.1522	1.0000	10.2505	9.8455	0.0681
	(0.1691)	(0.0000)	(1.7100)	(4.1515)	
PSA	0.5015	0.6011	50.9839	50.5150	0.1990
	(0.2022)	(0.2846)	(7.0689)	(11.0474)	
PZL	0.6640	0.0000	142.0709	46.0218	0.0971
	(0.1363)	(0.0000)	(16.9787)	(14.1095)	
RI	0.3000	0.0000	133.1176	118.5483	0.1178
	(0.1732)	(0.0000)	(8.3803)	(26.0086)	
RYL	1.0000	0.0000	254.1156	109.2416	0.1769
	(0.0000)	(0.0000)	(47.2888)	(15.2444)	
SBR	0.3567	0.0000	14.0389	13.7989	0.1492
	(0.2460)	(0.0000)	(2.4439)	(7.1138)	
SCL	0.3000	0.0000	24.5879	58.0742	0.2616
	(0.1731)	(0.0000)	(8.5231)	(19.4151)	
SEL	0.7203	1.0000	5.2582	6.5021	0.3081
	(0.2035)	(0.0000)	(0.8472)	(1.3459)	
SKP	0.6125	0.8784	17.5444	18.6311	0.2454
	(0.4482)	(0.5667)	(8.5802)	(6.4137)	
SLB	1.0000	0.0000	1572.0336	457.7149	0.1271
	(0.0000)	(0.0000)	(96.9605)	(71.2763)	
STW	0.3000	0.0000	24.5294	56.8039	0.2578
	(0.1732)	(0.0000)	(5.2248)	(14.2064)	
T	1.0000	0.6693	12.9585	3.6857	0.1245
	(0.0000)	(0.1726)	(5.0888)	(1.5769)	
TDP	0.4982	0.0000	8.5116	10.9928	0.2434
	(0.1814)	(0.0000)	(1.7124)	(2.1673)	
TEO	0.2981	0.0000	177.0134	119.6760	0.0915
	(0.1643)	(0.0000)	(18.3112)	(34.9000)	
TLD	0.1000	0.0000	40.9473	45.0468	0.0521
	(0.1134)	(0.0000)	(4.2051)	(4.2016)	
TSM	0.0000	0.6005	445.2094	184.5669	0.0000
	(0.0000)	(0.5077)	(0.1293)	(0.1112)	
TSO	0.5259	0.0000	82.3194	41.9518	0.1182
	(0.1634)	(0.0000)	(9.7336)	(7.5779)	
UCU	0.8968	1.0000	350.2658	141.0754	0.1530
	(0.0452)	(0.0000)	(23.9472)	(44.2333)	
USU	0.4862	0.0000	68.7179	52.9897	0.1579
	(0.1626)	(0.0000)	(7.4516)	(9.2205)	
VCV	0.1795	0.0000	5.4779	9.1578	0.1305
	(0.1445)	(0.0000)	(1.0852)	(2.4512)	
VIM	0.5129	0.9049	6.2195	6.3581	0.2077
	(0.1940)	(0.3247)	(1.4935)	(2.3935)	
VLY	0.5598	0.8278	90.2124	48.7197	0.1313
	(0.1898)	(0.2060)	(11.1022)	(12.2435)	
WES	0.3855	0.0840	19.6600	27.7046	0.2136
	(0.1587)	(0.4550)	(6.3106)	(9.0045)	
WLT	0.2000	0.0000	37.9999	75.4990	0.1658
	(0.1512)	(0.0000)	(7.0669)	(13.1371)	
WNC	0.3022	1.0000	85.1500	59.2296	0.0951
	(0.1703)	(0.0000)	(11.0425)	(10.6117)	

Appendix 1 Table F Continued

$$PIN = \frac{\mu(1 - P_n(t))}{2\varepsilon + \mu(1 - P_n(t))}$$

Pre 2001	ALPHA	DELTA	ETA	MU	PIN
WPI	1.0000	0.0000	457.7238	220.5432	0.1941
	(0.0000)	(0.0000)	(34.3961)	(22.8723)	
WRC	0.3011	0.0000	10.0597	22.8515	0.2548
	(0.1737)	(0.0000)	(1.4360)	(8.4911)	
ZAP	0.3071	0.6535	22.7730	16.4580	0.0999
	(0.1747)	(0.7267)	(3.7709)	(4.6119)	

Appendix 1 Table G: The Probability of Informed Trading (PIN) for NYSE Companies During 2001 Post-Decimalization Period

$$PIN = \frac{\mu(1 - P_n(t))}{2\varepsilon + \mu(1 - P_n(t))}$$

Post 2001	ALPHA	DELTA	ETA	MU	PIN
AC	0.3009	1.0000	383.6584	398.4346	0.1351
	(0.1735)	(0.0000)	(61.0026)	(144.6185)	
AGE	0.3996	0.2502	483.2162	227.6318	0.0860
	(0.1979)	(0.2799)	(30.9855)	(49.5518)	
AHG	0.3995	0.0000	197.1435	103.9057	0.0953
	(0.1844)	(0.0000)	(11.0514)	(31.7732)	
AK	0.2000	0.5011	55.0562	130.4379	0.1915
	(0.1633)	(0.4583)	(16.8931)	(43.0849)	
ALZ	0.8575	0.8710	4.9832	4.8203	0.2932
	(0.1731)	(0.2277)	(1.3806)	(2.2368)	
AMN	0.0000	0.5783	14.4798	8.4864	0.0000
	(0.0000)	(1.7812)	(5.0966)	(2.4697)	
AMU	0.1000	1.0000	8.4211	18.5767	0.0994
	(0.1134)	(0.0000)	(1.4042)	(1.4044)	
APA	1.0000	0.0000	921.2912	270.4642	0.1280
	(0.0000)	(0.0000)	(62.0104)	(50.4414)	
APX	0.4985	0.0000	10.8845	8.2866	0.1595
	(0.7399)	(0.0000)	(1.6536)	(7.9328)	
ATS	0.2006	0.5015	5.9432	17.5150	0.2282
	(0.1635)	(0.4585)	(0.9339)	(2.5887)	
BA	0.5882	0.4572	1414.3289	262.2114	0.0517
	(0.1861)	(0.3232)	(51.5502)	(61.3194)	
BAC	1.0000	1.0000	518.2864	216.2664	0.1726
	(0.0000)	(0.0000)	(0.0000)	0.0000	
BAX	0.4012	0.4971	699.9321	232.3910	0.0624
	(0.1966)	(0.3209)	(36.2656)	(36.0652)	
BKH	0.6451	1.0000	127.2027	33.0110	0.0772
	(0.1564)	(0.0000)	(12.1152)	(11.9051)	
BLX	0.8974	0.7794	5.2024	13.2555	0.5334
	(0.1228)	(0.1803)	(1.7114)	(1.7058)	
BMT	1.0000	0.0000	11.0000	7.8000	0.2617
	(0.0000)	(0.0000)	(2.8240)	(1.4815)	
BNO	0.4218	0.7593	20.0310	21.6647	0.1857
	(0.2461)	(0.3146)	(3.0516)	(8.8614)	
BQT	0.6976	1.0000	20.1593	8.0006	0.1216
	(0.3530)	(0.0000)	(2.2025)	(3.5709)	
C	1.0000	1.0000	326.2997	122.2683	0.1578
	(0.0000)	(0.0000)	(102.1917)	(39.0272)	
CBA	0.2666	1.0000	20.3491	19.5132	0.1133
	(0.1460)	(0.0000)	(2.5718)	(4.9635)	
CD	1.0000	1.0000	779.2040	428.3936	0.2156
	(0.0000)	(0.0000)	(53.4156)	(199.4575)	
CNE	0.4371	0.2244	5.0314	8.7790	0.2761
	(0.2229)	(0.2707)	(1.7661)	(2.5484)	

Appendix 1 Table G Continued

$$PIN = \frac{\mu(1 - P_n(t))}{2\varepsilon + \mu(1 - P_n(t))}$$

Post 2001	ALPHA	DELTA	ETA	MU	PIN
COE	0.3243	0.6749	26.6860	15.1934	0.0845
	(0.1512)	(0.5151)	(3.6743)	(4.6512)	
COO	0.6839	0.0000	106.6305	62.4941	0.1669
	(0.1517)	(0.0000)	(11.3404)	(10.1086)	
DEL	0.2826	0.4376	17.0476	25.1399	0.1724
	(0.1601)	(0.5016)	(4.9663)	(10.3081)	
DIS	0.0000	1.0000	1861.9000	936.1551	0.0000
	(0.0000)	(0.0000)	(86.6531)	(0.0000)	
DOL	0.4778	0.5025	188.3027	93.3257	0.1059
	(0.3012)	(0.5938)	(33.8692)	(37.1703)	
DY	0.5982	1.0000	463.1883	153.1732	0.0900
	(0.1835)	(0.0000)	(24.5710)	(32.6209)	
E	0.5815	0.0000	56.7973	44.3739	0.1851
	(0.1902)	(0.0000)	(5.6517)	(8.6566)	
EGP	0.5478	0.0000	39.3645	22.7667	0.1367
	(0.3973)	(0.0000)	(6.8428)	(11.4931)	
EL	1.0000	0.4113	428.0427	131.2715	0.1330
	(0.0000)	(0.1718)	(24.0099)	(37.3863)	
ESF	0.4918	0.7541	35.9280	22.4570	0.1332
	(0.1939)	(0.2790)	(3.6742)	(4.6056)	
ETN	0.4943	0.0000	282.4493	96.1003	0.0776
	(1.0069)	(0.0000)	(52.4229)	(85.7988)	
ETT	0.5332	0.6334	11.2781	12.2722	0.2249
	(0.1614)	(0.2796)	(2.3367)	(2.4969)	
FCF	0.2046	1.0000	20.5316	28.5326	0.1245
	(0.1523)	(0.0000)	(2.5619)	(3.5661)	
FOE	0.4079	0.2422	98.3204	34.7106	0.0672
	(0.1716)	(0.4921)	(10.2014)	(9.4843)	
FRT	0.7917	0.0000	59.0851	31.7420	0.1754
	(0.1565)	(0.0000)	(4.8382)	(2.9998)	
FTS	0.4868	0.7202	135.4701	102.6371	0.1557
	(0.2894)	(0.3369)	(33.0221)	(49.0568)	
GAM	0.3206	0.6478	20.8449	15.6258	0.1073
	(0.1787)	(0.4194)	(2.8080)	(2.7603)	
GFF	0.3962	0.7504	32.1307	56.8850	0.2597
	(0.1931)	(0.2834)	(6.9559)	(18.7286)	
GLW	1.0000	0.7161	144.7377	25.7810	0.0818
	(0.0000)	(0.1880)	(53.3903)	(18.4941)	
GRB	0.5947	0.6669	38.8671	32.2303	0.1978
	(0.1910)	(0.2513)	(5.4047)	(6.2967)	
GVA	0.1000	0.0000	115.6842	121.3158	0.0498
	(0.1134)	(0.0000)	(8.9881)	(8.9881)	
HMX	0.2046	1.0000	19.2608	24.3294	0.1144
	(0.1473)	(0.0000)	(3.2725)	(7.0400)	
IMT	0.2061	1.0000	10.8974	12.6421	0.1068
	(0.1527)	(0.0000)	(1.4124)	(1.7808)	
ION	0.3036	0.2438	37.8945	25.7272	0.0934
	(0.1832)	(0.8264)	(4.9862)	(5.2882)	
IPP	0.1000	0.0000	26.6841	40.3103	0.0702
	(0.1134)	(0.0000)	(1.0629)	(1.0607)	

Appendix 1 Table G Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

Post 2001	ALPHA	DELTA	ETA	MU	PIN
IQM	0.7140	1.0000	6.8509	8.8205	0.3149
	(0.2027)	(0.0000)	(1.2193)	(2.1069)	
JP	1.0000	0.2106	342.2374	103.6367	0.1315
	(0.0000)	(0.2070)	(36.8570)	(34.0631)	
KSS	0.3000	0.6666	1217.5854	284.3866	0.0338
	(0.1870)	(0.3518)	(60.9110)	(63.3255)	
LDG	0.3960	0.0000	136.2386	82.8800	0.1075
	(0.1752)	(0.0000)	(9.6949)	(17.8287)	
LFG	0.3048	0.3492	101.4470	79.4064	0.1066
	(0.1831)	(0.4225)	(14.5401)	(22.6880)	
LU	1.0000	0.5553	124.1732	13.4217	0.0513
	(0.0000)	(0.1942)	(47.8672)	(10.0816)	
MDA	0.3766	0.2336	25.0348	36.1898	0.2140
	(0.2994)	(0.9759)	(8.4252)	(20.7208)	
MHK	0.0000	0.0000	97.7898	46.6041	0.0000
	(0.0000)	(0.0000)	(21.6331)	(15.7917)	
MHO	0.7071	0.7189	14.5017	16.8234	0.2909
	(0.6547)	(0.4496)	(6.6278)	(5.6270)	
MIL	0.3000	0.0000	348.9420	262.7289	0.1015
	(0.1731)	(0.0000)	(23.7837)	(65.3076)	
MM	0.2000	1.0000	87.8333	88.1667	0.0912
	(0.1512)	(0.0000)	(6.8909)	(9.5299)	
MO	1.0000	0.1000	1706.0445	565.1924	0.1421
	(0.0000)	(0.1115)	(80.8752)	(102.9633)	
MU	1.0000	0.0000	2674.7604	460.2392	0.0792
	(0.0000)	(0.0000)	(146.2156)	(93.5369)	
MUO	1.0000	0.2946	5.3162	13.1676	0.5533
	0.0000	(0.1736)	(2.1721)	(2.1052)	
NGI	1.0000	1.0000	2.9000	2.9000	0.3333
	(0.0000)	(0.0000)	(0.3335)	(0.8132)	
NR	0.6173	0.0000	110.4660	54.8631	0.1329
	(0.1857)	(0.0000)	(11.3699)	(9.1533)	
NUC	0.0000	1.0000	8.5000	0.0000	0.0000
	(0.0000)	(0.0000)	(1.1279)	(0.0000)	
PAI	0.8249	0.2916	4.6179	6.1390	0.3541
	(0.2147)	(0.2415)	(1.2296)	(1.9701)	
PCG	0.0000	1.0000	891.4997	338.1721	0.0000
	(0.0000)	(0.0000)	(97.1145)	(2.38E+17)	
PEI	0.4790	0.0000	45.0014	29.4333	0.1354
	(0.3659)	(0.0000)	(8.4499)	(13.9601)	
PIM	0.8586	0.4737	59.0679	19.0593	0.1217
	(0.3299)	(0.2573)	(7.1134)	(3.7435)	
PKE	0.5985	0.0000	131.7855	53.1820	0.1077
	(0.1774)	(0.0000)	(11.3485)	(14.8130)	
PNM	0.5004	0.2898	220.2962	95.5425	0.0979
	(0.2028)	(0.3322)	(30.4551)	(30.7230)	
POS	0.4000	0.0000	162.7500	104.2500	0.1136
	(0.1852)	(0.0000)	(11.9184)	(14.0295)	
PPL	0.0000	1.0000	424.6939	138.8343	0.0000
	(0.0000)	(0.0000)	(308.5871)	(18103.7634)	

Appendix 1 Table G Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

Post 2001	ALPHA	DELTA	ETA	MU	PIN
PPM	0.2193	0.0000	8.4628	12.1928	0.1364
	(0.1637)	(0.0000)	(1.2970)	(2.1198)	
PSA	0.3667	0.8262	54.6275	22.2103	0.0694
	(0.5441)	(1.4292)	(9.0772)	(10.5091)	
PZL	0.4083	0.3565	183.7486	57.0684	0.0596
	(0.3682)	(0.4499)	(19.8263)	(23.1910)	
RI	0.4003	0.4749	143.0557	54.6797	0.0711
	(0.1897)	(0.3664)	(15.0378)	(20.1722)	
RYL	0.5000	0.6000	269.0000	152.4000	0.1241
	(0.2041)	(0.2828)	(23.2033)	(33.5400)	
SBR	0.7652	0.4868	6.4336	9.8445	0.3693
	(0.3050)	(0.2622)	(1.2166)	(2.2094)	
SCL	0.2000	1.0000	7.2778	34.7222	0.3230
	(0.1512)	(0.0000)	(2.5651)	(3.4607)	
SEL	0.3823	1.0000	5.9743	5.1040	0.1404
	(0.1357)	(0.0000)	(1.3571)	(1.5596)	
SKP	0.3772	0.5274	11.2367	17.0357	0.2224
	(0.1802)	(0.4345)	(3.0358)	(3.0708)	
SLB	0.8996	0.0000	1640.4111	518.3222	0.1244
	(0.1127)	(0.0000)	(66.9635)	(91.3638)	
STW	0.5005	0.0000	19.2074	25.7469	0.2512
	(0.1878)	(0.0000)	(4.0572)	(4.5802)	
T	1.0000	0.7951	3.6881	1.3144	0.1512
	(0.0000)	(0.1540)	(1.4312)	(0.6169)	
TDP	0.2000	0.5000	10.5558	33.9454	0.2433
	(0.1633)	(0.4567)	(1.3866)	(12.0493)	
TEO	0.0000	0.0000	172.4379	57.7291	0.0000
	(0.0000)	(0.0000)	(13.7018)	(18.5474)	
TLD	0.2995	1.0000	29.3032	31.7030	0.1394
	(0.1718)	(0.0000)	(3.6108)	(5.6529)	
TSM	0.5943	0.1587	517.4363	244.8557	0.1233
	(0.1934)	(0.3069)	(54.4736)	(46.5649)	
TSO	0.5007	0.1997	110.5166	108.3853	0.1971
	(0.2000)	(0.2302)	(16.8528)	(28.6575)	
UCU	0.7988	0.1244	276.8994	92.0180	0.1172
	(0.1558)	(0.1518)	(33.8202)	(33.1028)	
USU	0.5556	0.7046	64.5137	26.7707	0.1034
	(0.9963)	(0.3657)	(14.5223)	(20.1315)	
VCV	0.0000	1.0000	6.7000	0.0000	0.0000
	(0.0000)	(0.0000)	(1.3908)	(0.0000)	
VIM	0.0000	1.0000	6.6500	0.0000	0.0000
	(0.0000)	(0.0000)	(1.2316)	(0.0000)	
VLY	0.3979	0.4737	62.5656	41.1366	0.1157
	(0.1906)	(0.4471)	(9.1362)	(12.7193)	
WES	0.1000	1.0000	34.7895	63.2105	0.0833
	(0.1134)	(0.0000)	(5.4061)	(5.4061)	
WLT	0.2927	0.6456	16.1902	19.8804	0.1523
	(0.1783)	(0.3708)	(2.5998)	(4.0076)	
WNC	0.5094	1.0000	80.6905	33.2161	0.0949
	(0.9235)	(0.0000)	(18.1668)	(23.5576)	

Appendix 1 Table G Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

Post 2001	ALPHA	DELTA	ETA	MU	PIN
WPI	0.8993	0.0000	422.2305	130.9253	0.1224
	(0.1124)	(0.0000)	(21.8748)	(20.3700)	
WRC	0.5934	0.4770	9.7622	10.4072	0.2403
	(0.2144)	(0.2847)	(2.2650)	(2.6937)	
ZAP	0.3352	1.0000	25.9832	34.7061	0.1829
	(0.1856)	(0.0000)	(8.2745)	(12.9455)	

Appendix 1 Table H: The Probability of Informed Trading (PIN) for NYSE Companies During 2002 Period

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

2002	ALPHA	DELTA	ETA	MU	PIN
AC	1.0000	0.0000	347.5866	143.6879	0.1713
	(0.0000)	(0.0000)	(55.4940)	(29.6981)	
AGE	1.0000	0.0000	857.7222	278.7287	0.1398
	(0.0000)	(0.0000)	(90.3118)	(39.8840)	
AHG	0.3000	0.0000	319.4107	169.5791	0.0738
	(0.1731)	(0.0000)	(28.9433)	(32.8958)	
AK	0.5228	1.0000	240.1091	76.6685	0.0770
	(0.2111)	(0.0000)	(28.1819)	(27.3943)	
ALZ	0.8484	1.0000	4.0199	3.1357	0.2486
	(0.5632)	(0.0000)	(1.0883)	(1.6646)	
AMN	0.0000	1.0000	56.4226	21.5184	0.0000
	(0.0000)	(0.0000)	(9.1872)	(6.3730)	
AMU	0.1492	1.0000	7.9791	12.3458	0.1035
	(0.1618)	(0.0000)	(0.9305)	(4.0534)	
APA	1.0000	0.0000	1484.4258	699.9164	0.1908
	(0.0000)	(0.0089)	(77.5813)	(196.5675)	
APX	0.4365	0.5182	5.9385	9.6745	0.2623
	(0.1966)	(0.3240)	(1.1516)	(1.5260)	
ATS	1.0000	1.0000	3.0000	2.2222	0.2703
	(0.0000)	(0.0000)	(1.0690)	(0.5849)	
BA	0.0000	0.0000	2127.3000	1039.4731	0.0000
	(0.0000)	(0.0000)	(74.0313)	(17343.5441)	
BAC	1.0000	0.2230	175.4884	38.2702	0.0983
	(0.0000)	(0.1635)	(64.5189)	(14.4824)	
BAX	1.0000	1.3874E-18	149.8277	141.8555	0.3213
	(0.0000)	(0.0000)	(48.0154)	(39.2300)	
BKH	0.4815	0.2076	248.3743	124.9327	0.1080
	(0.2527)	(0.3024)	(35.4261)	(35.1834)	
BLX	0.3990	0.7337	77.3499	90.2152	0.1888
	(0.1939)	(0.3135)	(13.5483)	(31.1066)	
BMT	0.3831	1.0000	8.0968	3.6710	0.0799
	(0.3322)	(0.0000)	(1.1108)	(2.9456)	
BNO	0.4389	0.4555	20.3633	23.6323	0.2030
	(0.2234)	(0.4772)	(3.4316)	(9.3239)	
BQT	0.1000	1.0000	16.9473	39.0486	0.1033
	(0.1134)	(0.0000)	(1.5438)	(1.5423)	
C	1.0000	0.4173	174.5711	38.1708	0.0986
	(0.0000)	(0.1875)	(64.2080)	(14.9973)	
CBA	0.2000	0.0000	65.5000	110.5000	0.1444
	(0.1512)	(0.0000)	(14.9016)	(16.3637)	
CD	1.0000	0.5535	166.5431	34.5555	0.0940
	(0.0000)	(0.1858)	(66.0617)	(14.2297)	
CNE	0.1345	0.0000	6.1388	9.0899	0.0905
	(0.1183)	(0.0000)	(1.2995)	(2.3874)	

Appendix 1 Table H Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

2002	ALPHA	DELTA	ETA	MU	PIN
COE	0.2000	0.0000	23.3889	35.6109	0.1321
	(0.1512)	(0.0000)	(2.0039)	(4.2785)	
COO	0.3007	1.0000	253.6267	133.8606	0.0735
	(0.1727)	(0.0000)	(12.4704)	(13.1133)	
DEL	0.2001	0.5076	38.0057	37.9300	0.0908
	(0.1633)	(0.4663)	(4.3981)	(5.8867)	
DIS	1.0000	1.0000	289.3986	99.9840	0.1473
	(0.0000)	(0.0000)	(94.3677)	(32.6515)	
DOL	0.9962	1.0000	526.1343	194.7726	0.1557
	(0.0016)	0.0000	(24.1745)	(40.4144)	
DY	0.5995	0.1661	293.8842	122.1498	0.1108
	(0.1974)	(0.1977)	(28.4034)	(30.9223)	
E	0.5393	0.0000	130.7876	81.4434	0.1438
	(0.4919)	(0.0000)	(30.6837)	(36.7703)	
EGP	0.5612	0.0000	92.9521	31.8860	0.0878
	(0.3325)	(0.0000)	(12.9834)	(10.8607)	
EL	0.4001	0.2499	555.6185	269.5917	0.0885
	(0.1995)	(0.2793)	(44.1929)	(85.1507)	
ESF	0.5679	0.8035	30.5038	24.9922	0.1887
	(0.1728)	(0.2369)	(9.3231)	(8.1815)	
ETN	0.5357	0.0000	529.9674	111.7577	0.0535
	(0.2487)	(0.0000)	(32.5545)	(32.6119)	
ETT	0.4125	0.6892	8.6264	11.9928	0.2228
	(0.1963)	(0.4399)	(2.1449)	(1.8211)	
FCF	0.3010	0.6529	79.6448	59.8326	0.1016
	(0.1860)	(0.3560)	(8.3572)	(12.3078)	
FOE	0.5006	1.0000	250.1201	104.7936	0.0949
	(0.1872)	(0.0000)	(27.1424)	(31.2627)	
FRT	0.0000	0.0000	136.8433	60.1220	0.0000
	(0.0000)	(0.0000)	(7.4114)	(25.7061)	
FTS	0.1997	0.0000	345.5295	430.2894	0.1106
	(0.1474)	(0.0000)	(43.4011)	(205.6169)	
GAM	0.2782	0.6190	25.5967	20.5126	0.1003
	(0.1906)	(0.4062)	(3.1694)	(6.5366)	
GFF	0.0000	1.0000	187.0282	81.0126	0.0000
	(0.0000)	(0.0000)	(26.4286)	(29.7052)	
GLW	1.0000	1.0000	190.9758	51.9657	0.1198
	(0.0000)	(0.0000)	(67.6926)	(24.2273)	
GRB	0.2000	0.5005	76.6671	91.3255	0.1064
	(0.1632)	(0.4582)	(9.7835)	(28.0348)	
GVA	0.1000	1.0000	499.9474	401.0526	0.0386
	(0.1134)	(0.0000)	(34.2549)	(34.2549)	
HMX	0.4511	0.4691	17.1764	15.3993	0.1682
	(0.1944)	(0.3780)	(3.5498)	(2.6307)	
IMT	0.7963	1.0000	8.6755	5.5871	0.2041
	(0.5091)	(0.0000)	(2.2415)	(2.5339)	
ION	0.0000	0.6695	99.0704	43.3910	0.0000
	(0.0000)	(2.9630)	(14.9675)	(0.0000)	
IPP	1.0000	0.9194	21.6621	8.3757	0.1620
	(0.0000)	(0.1535)	(2.8797)	(3.0578)	

Appendix 1 Table H Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

2002	ALPHA	DELTA	ETA	MU	PIN
IQM	0.0000	0.7965	8.8000	0.0000	0.0000
	(0.0000)	(0.0000)	(1.0253)	(0.0000)	
JP	1.0000	0.0000	687.9272	250.0796	0.1538
	(0.0000)	(0.0000)	(74.4714)	(22.2112)	
KSS	1.0000	0.0967	1309.0653	265.4829	0.0921
	(0.0000)	(0.1143)	(95.1677)	(65.5825)	
LDG	0.5433	0.3575	357.7972	71.0547	0.0512
	(0.2642)	(0.2990)	(23.5256)	(20.7911)	
LFG	0.2000	1.0000	153.2222	137.7778	0.0825
	(0.1512)	(0.0000)	(16.6422)	(38.7644)	
LU	0.5874	0.9937	2.2737	0.4334	0.0530
	(0.2398)	(0.0081)	(0.9567)	(0.2852)	
MDA	0.2971	1.0000	8.3969	12.4751	0.1808
	(0.1713)	(0.0000)	(1.6026)	(2.9561)	
MHK	1.0000	0.3734	538.2990	220.5719	0.1700
	(0.0000)	(0.1377)	(97.9057)	(47.2473)	
MHO	0.5002	0.8046	212.2802	115.2375	0.1195
	(0.2035)	(0.2300)	(19.5560)	(24.8139)	
MIL	1.0000	0.0000	441.7556	134.1167	0.1318
	(0.0000)	(0.0000)	(38.1079)	(28.9123)	
MM	0.4000	0.7499	143.3121	127.4335	0.1510
	(0.1999)	(0.2797)	(16.6299)	(22.6734)	
MO	0.0000	0.0000	2494.5500	787.0744	0.0000
	(0.0000)	(0.0000)	(152.8304)	(0.0000)	
MU	1.0000	0.1998	90.2578	35.2896	0.1635
	(0.0000)	(0.1511)	(33.3154)	(13.4330)	
MUO	0.6000	0.5000	29.2857	224.2142	0.6967
	(0.2000)	(0.2635)	(10.8340)	(42.5472)	
NGI	0.5718	1.0000	2.6598	5.3874	0.3667
	(0.2728)	(0.0000)	(0.5952)	(1.4406)	
NR	0.7003	0.7197	145.4950	76.9840	0.1563
	(0.1865)	(0.2201)	(15.0138)	(18.2482)	
NUC	0.5196	0.0000	9.8940	9.0681	0.1923
	(0.2588)	(0.0000)	(1.6393)	(4.0846)	
PAI	0.6188	0.7323	3.8914	4.8758	0.2794
	(0.3199)	(0.3128)	(1.2458)	(1.4337)	
PCG	0.2000	1.0000	976.5556	400.9444	0.0394
	(0.1512)	(0.0000)	(45.6981)	(74.0123)	
PEI	0.3748	0.2741	63.8537	46.9348	0.1211
	(0.4065)	(0.3742)	(11.1292)	(29.9668)	
PIM	0.2564	1.0000	65.2837	28.5982	0.0532
	(0.1960)	(0.0000)	(3.1771)	(10.0112)	
PKE	0.0000	0.0000	206.2807	70.0706	0.0000
	(0.0000)	(0.0000)	(127154.9570)	(1.99E+09)	
PNM	0.2000	1.0000	510.3877	163.0902	0.0310
	(0.1512)	(0.0000)	(19.7367)	(23.3357)	
POS	0.6969	0.0000	346.1698	132.5307	0.1177
	(0.1694)	(0.0000)	(18.4541)	(14.6990)	
PPL	0.4000	0.0000	911.5625	309.4375	0.0636
	(0.1852)	(0.0000)	(41.2881)	(47.5207)	

Appendix 1 Table H Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

2002	ALPHA	DELTA	ETA	MU	PIN
PPM	0.1714	1.0000	6.8906	5.3604	0.0625
	(0.1766)	(0.0000)	(0.8689)	(2.6257)	
PSA	0.6841	0.0000	156.8907	71.2138	0.1344
	(0.3658)	(0.0000)	(17.6243)	(10.8806)	
PZL	0.6008	0.5357	298.6119	90.8324	0.0837
	(0.1928)	(0.2961)	(21.9893)	(25.8953)	
RI	0.3000	0.0000	541.0588	307.6078	0.0786
	(0.1732)	(0.0000)	(46.1029)	(54.0393)	
RYL	1.0000	0.0000	9.7004	2.5878	0.1177
	(0.0000)	(0.0000)	(3.3662)	(1.2035)	
SBR	0.4899	1.0000	74.3840	46.2005	0.1320
	(0.1549)	(0.0000)	(11.6402)	(12.0505)	
SCL	0.1000	0.0000	19.8421	45.1578	0.1022
	(0.1134)	(0.0000)	(3.0920)	(3.0919)	
SEL	0.0000	0.6279	9.5500	0.0000	0.0000
	(0.0000)	(0.0000)	(2.3749)	(0.0000)	
SKP	0.6022	0.8353	37.3013	26.2309	0.1747
	(0.1981)	(0.1976)	(2.7725)	(6.0328)	
SLB	1.0000	0.0000	2119.3505	394.2904	0.0851
	(0.0000)	(0.0000)	(143.6450)	(68.0677)	
STW	0.2000	0.0000	51.8333	75.6666	0.1274
	(0.1512)	(0.0000)	(8.3167)	(16.3611)	
T	1.0000	0.9000	2276.6933	451.7218	0.0903
	(0.0000)	(0.1115)	(118.3806)	(92.1257)	
TDP	0.2059	0.5502	5.2895	11.2743	0.1799
	(0.1638)	(0.4342)	(0.8054)	(3.1576)	
TEO	0.4000	0.7500	169.3125	110.6873	0.1156
	(0.2000)	(0.2795)	(21.1372)	(23.2785)	
TLD	0.3009	0.0000	75.6917	76.8355	0.1325
	(0.1707)	(0.0000)	(16.0540)	(24.0938)	
TSM	1.0000	0.5763	1033.8742	219.1037	0.0958
	(0.0000)	(0.1655)	(119.9335)	(55.6504)	
TSO	0.3000	0.3331	229.6477	189.3486	0.1101
	(0.1871)	(0.3512)	(19.7032)	(59.8047)	
UCU	0.4989	1.0000	670.7386	151.7875	0.0534
	(0.1860)	(0.0000)	(29.6119)	(30.6026)	
USU	0.4000	0.5000	135.5010	101.7390	0.1306
	(0.1997)	(0.3228)	(17.3964)	(32.5842)	
VCV	0.9654	0.0000	3.2006	2.3813	0.2642
	(0.5504)	(0.0000)	(0.4054)	(1.5933)	
VIM	0.3831	0.4083	6.1443	9.1646	0.2222
	(0.2443)	(0.4329)	(1.4955)	(3.1677)	
VLY	0.1997	0.0000	90.7300	63.3038	0.0651
	(0.1506)	(0.0000)	(7.6180)	(18.3814)	
WES	0.3001	0.3337	54.4687	65.1772	0.1522
	(0.1868)	(0.3522)	(7.8798)	(10.3740)	
WLT	0.3001	0.3338	142.5852	126.0461	0.1171
	(0.1865)	(0.3472)	(14.3424)	(44.2899)	
WNC	0.2000	1.0000	84.8889	133.1111	0.1356
	(0.1512)	(0.0000)	(13.4502)	(20.8347)	

Appendix 1 Table H Continued

$$PIN = \frac{\mu(1-P_n(t))}{2\varepsilon + \mu(1-P_n(t))}$$

2002	ALPHA	DELTA	ETA	MU	PIN
WPI	0.3000	0.6667	838.3529	373.9803	0.0627
	(0.1871)	(0.3514)	(47.6225)	(120.6906)	
WRC	0.4990	0.0000	192.1069	82.7310	0.0970
	(0.1857)	(0.0000)	(16.1933)	(19.8981)	
ZAP	0.2956	0.7190	3.7760	7.9420	0.2372
	(0.1789)	(0.4360)	(1.0596)	(1.2518)	

Vita

Timothy Shawn Strother was born in Fayetteville, NC on June 11, 1970. He was raised in Fayetteville, NC, but moved to Panama City, Panama in January 1987. He graduated from Balboa High School in Panama City, Panama in May 1988. Upon graduation, he returned to North Carolina where he attended East Carolina University and received a B.S. in business administration in May 1992. Shawn worked as a Financial Advisor for various firms from 1992 to 1997. He returned to East Carolina University in 1997 to pursue a graduate degree in business administration. After completing the MBA program, he moved to Knoxville, TN to pursue doctoral studies at the University of Tennessee, Knoxville. He is currently teaching finance at East Carolina University while completing his doctoral degree requirements.