In Search of Liquidity in the Internet Era

Ananth Madhavan
Investment Technology Group, Inc.[1]

Presented at
The Federal Reserve Bank of Atlanta
2000 Financial Markets Conference
Sea Island, Georgia
October 15–17, 2000

This article explores the profound and permanent impact the Internet has had on the trading environment. For example, entirely new information sources provide on-line traders with up-to-date information, reducing the information gap between institutional and retail investors. Simultaneously, the growing automation of securities markets has reduced trading costs. Together with the globalization of markets, these factors have induced large numbers of retail traders to enter the market directly. The information available on the Internet serves as a coordination device for on-line traders, who tend to respond in similar ways to the same information signals. According to the author, the result has been sharply higher intraday price volatility and diminished liquidity. In the short run, these phenomena represent the dark side of the Internet revolution. But information and automation also permit cross-border linkages that allow traders to access and link pools of liquidity in very disparate forms. In the long term, network externalities provide strong incentives for markets to create both formal and informal linkages, deepening markets and improving price efficiency.

[1] The views expressed here are those of the author alone and do not necessarily represent those of ITG, Inc., or its officers.

In Search of Liquidity in the Internet Era

The Internet has had a profound and permanent impact on the trading environment, a change that is nothing short of revolutionary. This revolution is far from over. Indeed, it has been accelerated by an unusual confluence of factors in the securities industry, including globalization, regulatory reforms, and technological changes that temporarily reversed a centuries-old trend toward greater market consolidation. While it is too early to speculate on the likely outcome of these trends, the broad outline is already apparent, at least in the near term. This paper explores the dramatic changes in the trading environment brought about by the information revolution and discusses the role of public policy in this context.

The rapidity of the transformation of markets and institutions creates a complex dilemma for policymakers. Faced with uncertainty concerning the future, it is difficult, and perhaps even dangerous, to pursue new policies and regulations for financial markets. Yet, in such a time of transformation, policymakers have a unique opportunity to shape the future. Their guidance and regulation is especially necessary at a time of market turmoil. With current conditions in mind, this paper examines the impact of the Internet on equity markets and focuses on market liquidity.

Liquidity is the lifeblood of financial markets; it is the necessary ingredient for price discovery. In the absence of liquidity, financial markets cannot provide accurate price signals to investors and corporations, signals that are crucial for efficient risk sharing and investment decisions. Further, there is growing evidence of a relation between liquidity and expected returns. In particular, Amihud and Mendelson (1986, 1991) find evidence of a positive relation between asset returns and bid-ask spreads.[2] Thus, liquidity directly affects a corporation's cost of capital and hence its willingness to undertake real investment. This link between financial market liquidity and the real economy is of considerable importance.

[2] Amihud, Mendelson, and Lauterbach (1997) document large changes in asset values for stocks moving to more liquid trading systems on the Tel Aviv Stock Exchange. Brennan and Subrahmanyam (1996) and Brennan, Chordia, and Subrahmanyam (1998) show that liquidity can explain the cross-sectional variation in returns.

This paper begins by discussing the key trends affecting markets today. In particular, recent changes have generally increased price volatility, a fact documented below. Nowhere is this increase in volatility more apparent than in intraday price swings. There is a fundamental inverse relation between price volatility and liquidity. Starting with volatility, price movements arise from two fundamental forces: (1) new information that causes shifts in the consensus beliefs of traders and (2) frictions arising from the trading process. Price volatility reflects the volatility of both of these forces and their joint interaction, factors that have been profoundly affected by the Internet revolution. Entirely new information sources, such as Internet chat room message traffic and whisper numbers (the investor's expectations for earnings), provide on-line traders with up-to-date information.

This "democratization of information" has reduced the information gap between institutional and retail investors. Simultaneously, the growing automation of securities markets has resulted in greater transparency and lower trading costs. These factors have induced large numbers of retail traders to enter the market directly at a time when markets are much faster. On-line traders respond to information flows in similar ways and over increasingly short horizons. Internet investors, reacting in real time, are often unaware that their actions are mirrored by large numbers of similarly informed traders. In effect, the Internet serves as a coordination device, amplifying the impact traders have on prices. Episodes of market manipulation based on Internet messages are an increasingly common and problematic manifestation of this phenomenon.

The overall effect of these trends has been sharply higher intraday price volatility, as documented here. In the short run these phenomena represent the dark side of the Internet revolution. But information and automation also allow cross-border linkages that permit traders to access and link pools of liquidity in very disparate forms. Network externalities provide strong incentives for markets to create both formal and informal linkages, deepening markets and improving price efficiency. These factors operate on a longer-term horizon. Technology thus lies at the heart of the current predicament but also offers the ultimate solution. Over the short term, however, the Internet's impact represents an immediate and severe challenge for regulators and policymakers charged with maintaining financial stability and market integrity. This paper explores this challenge in detail.

The next section of this paper outlines the major trends driving the structural change in financial markets. The discussion focuses on the U.S. equity markets because the changes there offer an

excellent illustration of the paper's thesis, but the conclusions are more general. The paper then examines how these trends exacerbate the impact of the Internet on markets and liquidity in particular. The concluding section offers recommendations for policymakers and regulators.

Secular Trends Affecting Financial Markets

It is useful to begin the investigation of the impact of the Internet on financial markets with a brief history of the determinants of market structure. Historically, securities markets were organized as auctions featuring physical trading floors. These markets, which largely prevailed until the advent of electronic markets in the late twentieth century, were forced to limit entry because of physical space constraints. They typically operated in a mutualized governance structure, selling a limited number of seats to ensure capacity constraints are met. The result could be categorized as a two-tier information structure, with substantial differences in the availability and quality of information between exchange participants and outside investors. In the absence of information linkages, securities markets were fragmented, offering isolated pools of liquidity.

Technology has been steadily breaking down the informational barriers that fragment markets, resulting in a secular trend toward market consolidation. A good example of this is the U.S. equity market. At the turn of the nineteenth century there were over a hundred stock exchanges in the United States, in all major cities as well as isolated mining towns in the Rocky Mountains. There were exchanges in Detroit, Buffalo, and even Colorado Springs. Technological innovations such as the telegraph and telephone, together with the Great Depression, led to the consolidation of all but a handful of exchanges. Similar forces operate in other countries and in other assets. Of course, there have been exceptions to this general secular trend. Indeed, new market mechanisms constantly arise to service the needs of heterogeneous traders. Examples include the development of Instinet and POSIT to service the needs of large institutional traders. Nonetheless, these cases are isolated instances in an otherwise worldwide trend for consolidation, driven by the power of network externalities and economies of scale.

But the recent trends in the market have temporarily reversed the powerful forces for consolidation, creating instead more fragmentation. Somewhat ironically, this reversal is associated with the information revolution, but it really has its roots in an unusual confluence of factors. Broadly speaking, the major trends in the market today can be thought of as falling under two categories: (1)

factors affecting market structure, including automation, exchange governance, regulatory change, and globalization, and (2) factors affecting information structure, especially those affecting the two-tier nature of information in the securities industry. It is in the latter category that the impact of the Internet has been most profound, but the changes in market structure, while exogenous to a large extent, have only served to amplify the effects of the Internet.

Market Structure Changes

Automation and Exchange Governance. The automated auction is transforming the landscape of securities markets. Unlike traditional markets, trading in an automated auction is through an electronic limit order book without the need for a physical exchange floor or designated market makers. Advantages of speed, simplicity, scalability, and cost drive the worldwide adoption of automated auctions to trade equities, bonds, foreign exchange, and derivatives.[3]

Automation has a mixed effect on liquidity. On the one hand, it reduces trading costs, which tends to encourage greater participation by investors, broadening liquidity. Conversely, automation increases the speed with which traders can react, and faster reaction times in turn create more volatility. One example is the development of quantitative trading strategies based on real-time information flows that are increasingly used by institutional traders. Automated systems also offer a high degree of transparency in that orders to buy or sell at stated prices are observed by the public. Such limit orders constitute free options, and there is some evidence that large traders are unwilling to show their hand by posting their true trading intentions.

An interesting facet of the move to automated auctions is the widespread demutualization of governance structures. Initiatives begin with a conversion to automated execution technology because there is no need to limit membership in the absence of a physical floor. For enterprises without a prior

[3] Outside the United States and a handful of emerging markets, virtually all equity and derivative trading systems are automated. A partial list of major automated markets includes, for equities, the Toronto Stock Exchange, Euronext (Paris, Amsterdam, Brussels), Borsa Italiana, National Stock Exchange (India), London Stock Exchange, Tradepoint, SEATS (Australian Stock Exchange), Copenhagen Stock Exchange, Deutsche Borse, and electronic communication networks such as Island. Fixed income examples include eSpeed, Euro MTS, BondLink, and BondNet. Foreign exchange examples are Reuters 2002 and EBS. Derivative examples include Eurex, Globex, Matif, and LIFFE. Domowitz (1993) provides a taxonomy of automated systems.

history of nonautomated operations, mutual structure is routinely avoided in favor of a for-profit, joint-stock company. These changes in exchange structure increase the pressure to automate. A partial list includes Stockholm Stock Exchange (1993), Helsinki Stock Exchange (1995), Copenhagen Stock Exchange (1996), Amsterdam Exchanges (1997), Borsa Italiana (1997), Australian Stock Exchange (1998), and possibly the Nasdaq and New York Stock Exchange (NYSE) in the future.

Traditional, mutualized exchanges frequently do not compete aggressively because their members often have multiple roles. For example, on the NYSE many members are also the exchange's customers and competitors as well as being owners. Demutualized exchanges, freed from such inherent conflicts and pressured by public investors, are likely to compete more aggressively, putting more pressure on explicit costs and also tending to fragment markets.

Regulatory Change. The biggest driver in today's marketplace is regulatory change. Three major thrusts deserve emphasis: increased competition, decimalization, and transparency.

Regulatory views worldwide have generally shifted in favor of allowing greater competition, as opposed to promoting policies that favor the centralization of trading in a primary market. In the U.S. equity markets this trend has led to heightened intermarket competition. One example is the SEC's order handling rules that opened the door for alternative trading systems and electronic communication networks in 1997. Competition occurs in many dimensions: for order flow, it occurs on a global basis; for new listings, it occurs between markets. This development puts pressure on explicit costs such as commissions, for which there are recorded charges. Since smaller retail traders do not trade in large size, explicit costs are their primary consideration. The opposite side of competition is fragmentation, however, and we now have a system with multiple pools of liquidity that are imperfectly linked. In such an environment, implicit costs (that is, the costs associated with moving the market itself through trading) become much larger. It should be noted that implicit costs constitute the great majority of trading costs (Keim and Madhavan 1998); thus, even relatively small increases in implicit costs might offset completely the reduction in explicit costs. In summary, the competitive pressures tend to favor the retail investor over the institutional investor.

The pressure for decimalization will push exchanges to reduce the minimum price increment. If this reduction occurs, past experience suggests that quoted bid-ask spreads will narrow. However, it is important to understand that this development does not mean more liquidity. In fact, the opposite may

occur because the reduction in minimum tick creates a disincentive to place limit orders. In turn, fewer shares are offered at the prevailing bid and offer prices, reducing liquidity. Having fewer limit orders at any given price also implies that a given order will move prices more, increasing what are known as the implicit costs of trading. Evidence from the recent shift of fifty-five stocks to decimals is too preliminary to confirm this hypothesis, but the data are consistent with what has been predicted. Spreads narrow but stated depths also fall. Similar findings were recorded with the shift from pricing in one-eighth increments to pricing in one-sixteenth increments. Again, these trends favor the retail investor over the institutional trader with large volumes to trade.

Another aspect of regulatory change is increased pressure for greater market transparency. Transparency refers to the quantity and quality of information provided to market participants during the trading process. Automated markets are typically highly transparent because they provide relevant information before (quotes, depths) and after (actual prices, volumes) trade occurs. By contrast, foreign exchange and corporate junk bond markets rely heavily on dealers to provide continuity but offer very little transparency. Other dealer markets (Nasdaq, the London Stock Exchange) offer moderate degrees of transparency. Higher transparency is beneficial to smaller retail investors who do not have access to the kinds of information market professionals possess. Nonetheless, transparency tends to increase the costs associated with trade for larger institutional traders because their intentions are easier to discern. This effect gives rise to front-running, where, for example, traders purchase shares if they know that a large buyer is in the market. Like decimalization, the impact of greater transparency may be to reduce liquidity for large block trades. Both initiatives tend to lower the value of placing a limit order. This effect reinforces the disadvantage, relative to the past, of the trader with large orders.

Globalization. Technology overcomes national barriers, and globalization induces the entry of new players. Like internal competition, the global competition for order flow tends to reduce explicit costs, such as commissions, but also spreads liquidity across different pools. In the past, a U.S. stock might trade only on the NYSE, but now it can be traded in several markets, not all of which are in the United States. The short-term impact of globalization on liquidity is thus to fragment the market. Eventually, network externalities may drive a consolidation of liquidity into one market for each major time zone. This process could take several years, perhaps even a decade or more, depending on the market. Foreign exchange and derivatives trading is likely to see consolidation faster than equities, and,

in turn, consolidation in fixed income appears years away, given the fragmented nature of the bond market.

Information Structure and the Internet

Today there are about 250 million users of the Internet, of whom about 10 million are on-line traders. The "democratization of information" refers to two phenomena brought about by the Internet: (1) more and generally better-quality information at lower or no cost, from old and new sources, is now available in real time; (2) millions of people see and act on this information in real time.

Both elements of the democratization of information have profound implications for markets. There are billions of Web pages covering company statements, SEC filings, business statistics, news, informed and uniformed speculation, and macroeconomic information. Much of this information is familiar (for example, government sources, news, earnings forecasts, and the like). Some sources are entirely new and are purely creatures of the Web, such as the information contained on the Raging Bull or Motley Fool message boards or the whisper number forecasts on TheWhisperNumber.com site.

The Internet is revolutionary not in that it allows easier access to the markets but in that it finally eliminates the two-tier information structure that categorized virtually all securities markets until the late twentieth century. Previously, market participants had substantial advantages over ordinary investors in terms of fundamental research about companies as well as real-time market data. To a large extent, the outside investor was unable to compete on a level playing field with market professionals. Now, individual investors have the ability to do detailed research on a few companies of interest. By contrast, institutional investors, with large trading lists of perhaps thousands of securities, face a severe disadvantage in a world where real-time information events occur on an ever more frequent basis. The democratization of information has reversed the traditional hierarchy of informational advantage. In addition, the technology of the Internet, with its open access, speed, and low cost, naturally disintermediates the traditional broker. The immediate consequence has been an increase in on-line trading, with almost half of all retail traders trading on-line.

New information sources imply more volume and more volatility. The move to electronic, automated systems puts more pressure on costs, especially explicit costs. Lower costs, a more level

information field, and greater transparency spur the entry of on-line traders. Such traders react, in real time, to common sources of news.

Implications for Volatility and Liquidity: The Coordination Problem

One aspect of the democratization of information is information overload. A second element is the reaction of investors to information across the Web. While the Yahoo! site draws much more traffic than does a local city paper, the local paper's Web site may still get hundreds of thousands of visitors, many of whom react to the information. If the same information appears almost simultaneously in different media and on different parts of the Web, a coordination problem exists. Consider, say, a negative story about Amazon.com in a leading financial newspaper. Investors read the original story, but many others hear about it secondhand through various sources. All react to it, and they react quickly. The result can be a wild swing in the stock price that occurs because each investor thinks he or she is among the first to see and act on the news. The source of this problem is that an individual investor does not know how many other people see the same news, how many of them respond to this news, and how aggressively they respond. In a statistical sense, the outcome of this uncertainty is an over- or underreaction of prices to new information.

Recent advances in behavioral finance suggest the typical reaction, at least for individuals, is overreaction, not underreaction. Specifically, there are strong evolutionary pressures for individuals to be overconfident in their assessments of a situation, and psychological studies dating back to the 1950s confirm this prediction. Overconfidence leads to volumes that are larger than expected, causing short-term price swings. Such effects have a further, negative feedback effect on liquidity. Essentially, higher volatility increases the value of the free option offered by a limit order trader when he or she commits to posting a bid or offer in an automated system. Higher volatility thins out the limit order book, creating holes that imply lower liquidity. Coppejans, Domowitz, and Madhavan (2000) provide evidence on this subject in the context of their study of the price dynamics in an automated market.

A Formalization

What is the impact of this coordination problem? Consider a prototypical market microstructure model where price changes reflect changes in consensus beliefs, *??*, and microstructure frictions. The

microstructure frictions are modeled as proportional to the signed order flow, ? ?, where the constant of proportionality, λ, is interpreted as the price impact coefficient. Formally, ? ? = ? ? + ?? ?. Observe that market depth in this model is $1/\lambda$, the order flow necessary to move prices by one unit. Thus, deeper markets correspond to lower values of λ.

Then price volatility reflects the variance of beliefs plus variance of frictions plus a covariance term. Formally, $s^2(?p) = s^2(?v) + \lambda^2 s^2(?x) + 2\lambda s(?v, ?x)$. The variance of beliefs is increasing in dispersion regarding fundamentals. The variance of signed order flow and the covariance of the change in beliefs and order flow is (1) increasing in number of on-line traders, because larger numbers of traders lead to larger volumes in general, (2) increasing in the common response of these traders to an information signal because these traders base their actions on signals that are correlated with the revision in beliefs in the first place, and (3) increasing as a function of the implicit trading costs associated with a trade, manifested by a higher price impact coefficient (less depth) that in turn arises from the unusual confluence of factors discussed earlier.

All three factors have been increasing; rising uncertainty over fundamentals and higher implicit costs also raise volatility. To the extent that higher volatility is the norm, the value to providing liquidity goes down because limit orders are free options to the market whose value goes up with volatility. The result is lowered liquidity, as explained in detail below.

The Power of the On-line Trader

An example of on-line traders' power amplified by the coordinating force of the Internet is the price reaction to messages—often false—posted in stock market–related Internet chat rooms. Cybermanipulations using message boards are purely an Internet phenomenon. The Internet gives the manipulator natural advantages—anonymity, speed, scalability (the ability to post messages on multiple boards at one point in time and to replicate those messages again and again), low cost, and high impact. Recent examples include situations involving Raytheon, Pairgain, Franklin, HealthSouth, COHO Energy, Ascend, Lucent Technologies, and many others, as discussed by Leinweber and Madhavan (forthcoming).

A typical case is that of Aastorm Biosciences. In February 2000, hackers posted a fake message on the Internet about a merger between Aastorm Biosciences, Inc., and Gerno Corporation

that stated that the merger price would be $11.79 per share for Aastorm Biosciences, Inc., which was then traded at about $4. The stock soared before the fraud was discovered, trading for up to $7.50, and Gerno jumped 26 percent to a fifty-two-week high of $59.625. Such cases are not confined to the smaller capitalization stocks; they have been documented in a variety of larger stocks as well. A good recent example is a false message posting concerning Lucent Technologies that caused the stock to drop, temporarily eliminating over $7 billion of market capitalization. The key point is that on-line investors responding to signals (false or otherwise) on the Internet can substantially affect stock prices, even for relatively large firms.

Volatility and Liquidity

Empirical estimates of price impact functions are difficult, but there is considerable indirect evidence that volatility has been rising and that this is especially evident for intraday volatility. Consider the following figures that provide a frequency distribution for the intraday price range.[4]

Figure 1 shows a dramatic increase in intraday volatility in 1999 relative to the previous three years. In each case, intraday volatility is defined as the intraday high price less the intraday low price, all divided by the previous day's closing price. While most commentators agree that daily volatility has been rising, the dramatic increase in intraday volatility is quite startling. In particular, observe the clustering of volatility at greater than 2.6 percent per day, the modal frequency in our sample in both 1998 and 1999.

High intraday volatility represents a substantial cost for large institutional traders because they might trade at prices very different from the closing prices against which these traders are typically benchmarked. Considerable empirical evidence (Keim and Madhavan 1998, 33–81) documents a systematic positive relation between implicit trading costs and volatility. Intraday volatility is one symptom of the lack of liquidity. To date in the year 2000, the pattern has been even more pronounced as shown in Figure 2.

[4] The statistics reported here are based on the author's estimates.

Volatility on the Nasdaq market is much greater than on the Standard and Poor's 500, but both markets exhibit considerable volatility relative to the levels shown in Figure 1. Decimalization may well worsen the short-run picture. Preliminary evidence from a variety of sources appears to confirm the hypothesis of a reduction in depth although spreads do narrow as conjectured. As noted, volatility discourages limit order traders from submitting orders. Faster markets also favor the use of market orders (liquidity demanding), as opposed to liquidity supply strategies using limit orders.

Policy Issues: Adaptive Behavior

To frame the discussion of the role of public policy, it is helpful to begin by discussing whether the market will self-correct in the sense that traders and institutions will develop responses to the trends identified herein. To the extent this occurs, the need for regulatory intervention is reduced.

In the short run, the heightened volatility and lack of liquidity will lead to adaptations by traders. Individual investors who trade individual names do not face the same problems as institutions. While the number of on-line traders will fluctuate with market returns, there will be a secular increase in their number as explicit costs continue to fall.

Institutional investors, with lists of thousands of names globally, cannot react fast enough. These investors need quantitative trading strategies that respond to real-time information flows and optimally allocate trades across liquidity pools, and they need to take advantage of time-varying liquidity. Coppejans, Domowitz, and Madhavan (2000) show that there might be significant gains to using discretionary trading strategies in the face of time-varying liquidity. Specifically, they anticipate that institutions will develop systems, products, and platforms that integrate the entire process of investment strategy and its implementation through trading. These include "intelligent" e-agents that consistently pick the optimal liquidity source across fragmented markets; trade dynamically in response to new information, existing market conditions, and order status; analyze post-trade performance and learn from experience; and adapt behavior. These strategies are already in the process of adoption by sophisticated quantitative managers, a trend expected to accelerate over the next few years.

Markets too will adapt. The secular trend for consolidation is an ever-present force that is only temporarily in abeyance. Indeed, the airline industry is in many ways a good model for the likely linkages expected in the financial markets. Powerful network externalities put strong pressure on markets,

especially those publicly traded, to form linkages. The exact form of these linkages is unimportant. They might occur through mergers, acquisitions, strategic alliances, pooling of order flow, or information-sharing agreements, as discussed by Domowitz and Steil (1999, 33–81). These arrangements are economically sensible and are technologically feasible given the recent developments in communications technology. Markets that fail to build alliances or linkages will find themselves isolated, with possibly devastating results. Again, the unification of diverse pools of liquidity does not require spatial consolidation; it can occur in cyberspace. The forces that drive short-run fragmentation will eventually be dominated by technological innovations that tend to consolidation.

Over slightly longer horizons, the trend toward automated auctions is expected to result in markets that are linked across asset classes. A good example is the Swedish market for stock index futures studied by Coppejans, Domowitz, and Madhavan (2000). They document very high resiliency in the sense that liquidity is quickly restored following exogenous shocks. It is likely that this high degree of resiliency reflects the fact that both the index futures and underlying stocks are traded in an automated auction that makes efficient spot-futures arbitrage possible. In the long run, the resiliency of markets is aided by the Internet since traders do not have to be physically close to place orders in response to a shock that evaporates available liquidity. Thus, over the long run, the natural forces of competition and technology will solve the same problems that they have created in the immediate present. This is not to say, however, that policy responses are not required.

Policy Responses

What can policymakers do to improve market quality and ensure the development of a sound foundation for the future? The discussion includes two parts: a discussion of regulation at the microlevel and a macrolevel discussion focusing on global integration.

At the microlevel, both institutional and retail traders have many choices that suit their differing objectives and strategies. It is doubtful that a one-size-fits-all approach to the markets is desirable. In practical terms this means that regulators should not try to mandate market structure; rather, they should let the markets evolve accordingly. A case in point is the National Market System mandated by Congress in 1975. Many interpretations of this ambiguous charge focus on the Consolidated Limit Order Book (CLOB) as an integral element of the system. But the creation of a CLOB would require

government intervention; simple linkages of existing markets will not preserve the strict price-time priority envisaged by proponents of the CLOB. While this market structure might have attractive features, it does not allow for systems like electronic communication networks to create value by providing users with new and desirable features that are not related to price. In reality, especially for institutional clients, best execution means more than simply best prices. Other factors—speed, reliability, anonymity, and the ability to hide orders in a reserve book—may also have considerable value. The current market system, although it appears unduly complex and fragmented, offers a variety of choices to different market participants. Essentially, heterogeneity in the investor population requires heterogeneity in trading systems. Only the market can provide such diversity. However, the exact boundaries of regulatory willingness to tolerate fragmentation have yet to be tested and remain a source of concern for market participants.

Consistency of regulatory response is also a key factor. Uncertainty concerning the direction of future regulatory changes complicates the task of traders and hinders the process of adaptation outlined above. To a large extent the goals of regulators have been relatively clear, with a strong focus on transparency, cost reduction, and intermarket competition. Certainly, in the present environment, these goals are not at all in conflict with the idea that markets themselves will be the ultimate arbiters of structure. A clearer definition of the future of regulation at the microlevel would facilitate the transition to a more rational market structure not only in equities but in other asset classes as well.

Investor protection is one area in which regulation can also improve market quality. An obvious focus is dampening excess volatility of the type discussed above. This objective requires tighter margin requirements for on-line traders coupled with aggressive policing of the Internet and close monitoring of message boards and chat rooms in real time. The Securities and Exchange Commission, for example, now devotes considerable resources to monitoring the Internet, but most efforts to date have been reactive rather than proactive. Regulators respond after egregious price movements and complaints of manipulation. The cases prosecuted to date involve relatively crude manipulations, and it is unclear whether more sophisticated manipulations remain undetected. The aggressive prosecution of such manipulators is an important element of a regulatory response designed to increase market quality.

At the macrolevel, the pressures on liquidity identified in this paper pose a more serious concern in the short run. The case of Long-Term Capital Management (LTCM), the hedge fund that failed last

year, is particularly appropriate. Although LTCM followed a number of supposedly market-neutral trading strategies diversified across regions and asset classes, the fund was ultimately humbled by a worldwide liquidity crisis that adversely affected all of its positions simultaneously. In an environment where liquidity is scarce and fragmented, such events are not unusual. Indeed, they may become increasingly likely. Some evidence that the market perceives risks in this dimension are evident in the unprecedented spreads for less liquid assets.

It is not clear whether there are explicit policies that central banks or others could implement to diminish by explicit regulation or policy initiatives the likelihood of such events. As noted above, the need for such regulation is likely to diminish over time as markets naturally consolidate. However, it is appropriate for regulators to be extremely vigilant and act quickly to supply liquidity when a crisis occurs. This strategy also requires coordination among policymakers across national boundaries given that order flows are increasingly unrestricted. Agreement on a common response to international liquidity crises would also constitute a major step toward improving market integrity on a worldwide basis. A key element of such a policy would be increased real-time monitoring of financial information and order flows in a variety of asset classes across national boundaries.

Conclusions

The Internet has had a profound and permanent impact on the trading environment. This paper explores the effect of the Internet on financial markets with a focus on liquidity, the crucial ingredient to price formation. The author argues that an unusual confluence of technological, regulatory, and competitive factors have temporarily reversed the secular trend toward greater market consolidation, resulting in higher volatility and greater fragmentation. Specifically, entirely new information sources, such as chat room message traffic and whisper numbers, provide on-line traders with up-to-date information. This democratization of information has reduced the information gap between institutional and retail investors.

Simultaneously, the growing automation of securities markets results in greater transparency and lower explicit trading costs, again favoring the small, retail investor. These factors have induced large numbers of retail traders to enter the market directly at a time when markets are much faster. On-line traders respond to information flows in similar ways. In effect, the Internet serves as a coordination

device, amplifying the traders' impact on prices. Increasingly common episodes of market manipulation based on Internet messages are a manifestation of this phenomenon. Simultaneously, a variety of coincident factors reduce market liquidity for large traders. The overall result has been diminished liquidity and sharply higher intraday price volatility, as documented here. In the short run, these phenomena represent the dark side of the Internet revolution.

Over the longer term, information and automation also allow cross-border linkages that allow traders to access and link pools of liquidity in very disparate forms. Network externalities provide strong incentives for markets to create both formal and informal linkages, deepening markets and improving price efficiency, much as they have for the past two centuries. In conclusion, the Internet poses an immediate and severe challenge for regulators and policymakers charged with maintaining financial stability and market integrity. This is especially important in a macroeconomic context where a global liquidity crisis requires coordination across different regulatory bodies and across national boundaries.

Appendix

Previous research has modeled expected returns as functions of variables including proxies for size and default risk. Amihud and Mendelson (1986) show that expected returns are a decreasing function of liquidity because investors must be compensated for the higher transaction costs that they bear in less liquid markets. This appendix demonstrates the positive relation between illiquidity and the cost of capital and shows that this effect is compounded when turnover or implicit trading costs increase.

For simplicity, assume a risk-neutral economy where the risk-free rate is r_f. Consider a security paying a stochastic dividend or interest coupon payment each period. Dividends are realized just after trading and are drawn from an independent and identically distributed distribution with mean d. Suppose, for simplicity, that each trader holds the security forever so that the immediate cost is all that is relevant.

In the absence of transaction costs, the expected present value of a security is simply $m^* = d/rf$. With trading costs, the purchase price is $p = m + (\lambda + s)$, where m is the midquote, s is the half bid-ask spread, and λ is the price impact of the trade. Under risk neutrality, a purchaser with a T-period horizon must be compensated for the round-trip trading costs so $m = m^* - [1 + (1 + r_f)^{-T}](\lambda + s)$.

The presence of trading costs (asymmetric information, inventory costs, and other transaction costs) reduces the equilibrium value of the asset. It follows that the expected rate of return on the asset is higher than the risk-free rate when λ or s are positive. The longer the holding horizon (or the shorter the turnover), T, is, the more the effect is reduced. Similar remarks apply to a reduction in implicit trading costs or the bid-ask spread.

References

Amihud, Yakov, and Haim Mendelson. 1986. Asset pricing and the bid-ask spread. *Journal of Financial Economics* 17 (December): 223–50.

———. 1991. Liquidity, maturity, and the yields on U.S. government securities. *Journal of Finance* 46 (September): 1411–26.

Amihud, Yakov, Haim Mendelson, and Beni Lauterbach. 1997. Market microstructure and securities values: Evidence from the Tel Aviv stock exchange. *Journal of Financial Economics* 45 (September): 365–90.

Brennan, Michael J., and Avanidhar Subrahmanyam. 1996. Market microstructure and asset pricing: On the compensation for illiquidity in stock returns. *Journal of Financial Economics* 41 (July): 441–64.

Brennan, Michael J., Tarun Chordia, and Avanidhar Subrahmanyam. 1998. Alternative factor specifications, security characteristics, and the cross-section of expected stock returns. *Journal of Financial Economics* 49 (September): 345–73.

Coppejans, Mark, Ian Domowitz, and Ananth Madhavan. 2000. Liquidity in an automated auction. Pennsylvania State University Working Paper.

Domowitz, Ian. 1993. A taxonomy of automated trade execution systems. *Journal of International Money and Finance* 12 (December): 607–31.

Domowitz, Ian, and Benn Steil. 1999. Automation, trading costs, and the structure of the securities trading industry. In *Brookings-Wharton Papers on Financial Services*, edited by Robert E. Litan and Anthony M. Santomero. Washington, D.C.: Brookings Institution Press.

Keim, Donald, and Ananth Madhavan. 1998. The cost of institutional equity trades: An overview. *Financial Analysts Journal* 54:50–69.

Leinweber, David J., and Ananth Madhavan. Forthcoming. Three hundred years of market manipulations. *Journal of Investing*.

Figure 1: Intraday Nasdaq Volatility, 1996–99

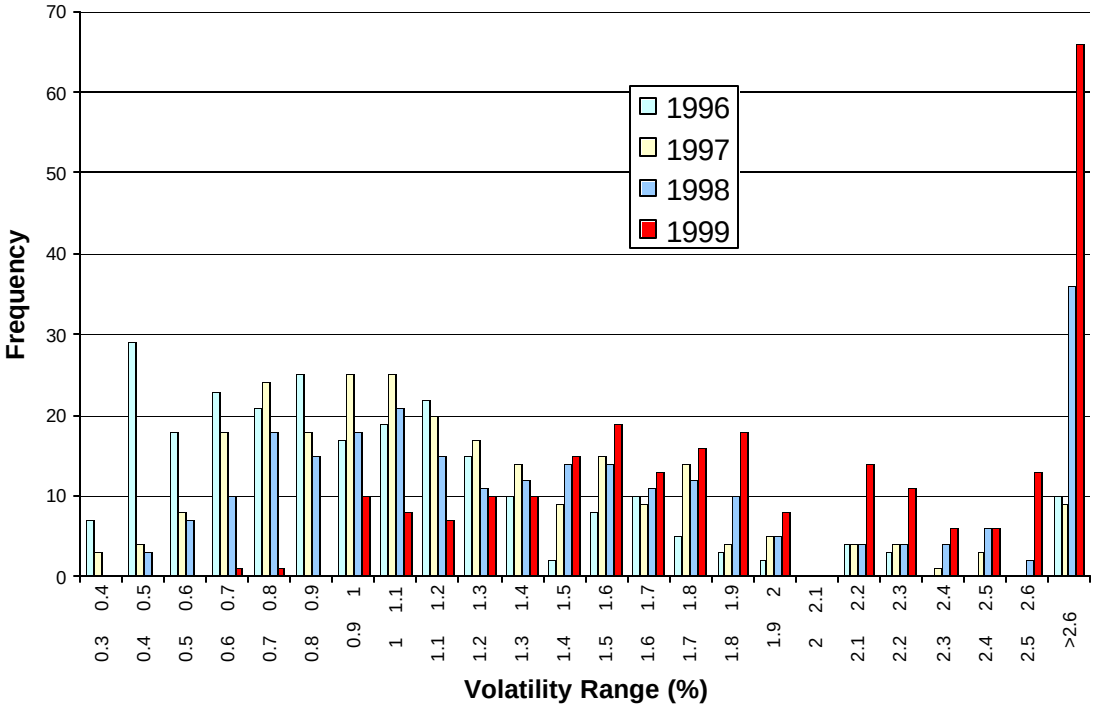
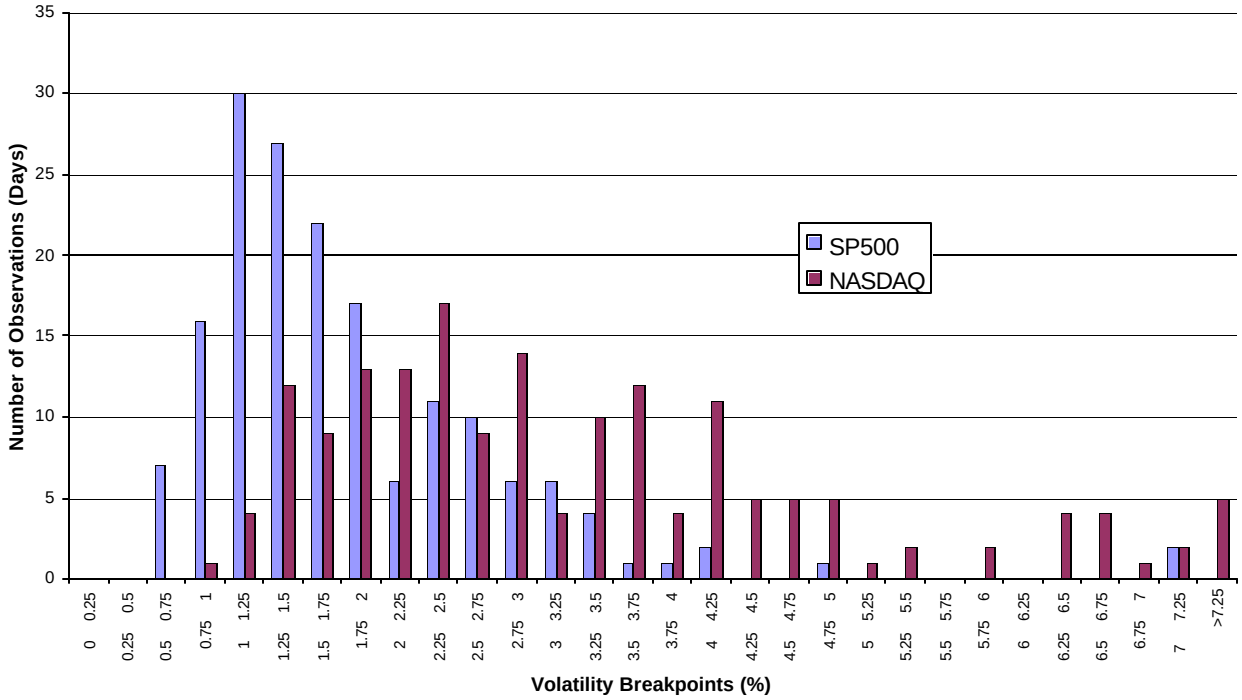
Figure 2: Intraday Volatility for S&P 500 and Nasdaq Stocks to September 2000