In Search of Liquidity in the Internet Era

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The Internet has had a profound and permanent impact on financial markets. This paper explores the dramatic changes brought about by the information revolution, and discusses the role of public policy in this context. We argue that an unusual confluence of technological, regulatory, and competitive factors have temporarily reversed the secular trend towards greater market consolidation. Specifically, the Internet has reduced the information gap between institutional and retail investors. Simultaneously, automation and regulatory initiatives have increased transparency and lowered trading costs. These factors contribute to the growth in online trading. Online traders respond to information flows in similar ways. In effect, the Internet serves as a coordination device, amplifying their impact on prices. The net effect is diminished liquidity and sharply higher intraday price volatility, as we document here. In the short-run, these phenomena represent the dark side of the Internet revolution. Over longer horizons, 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 policy makers charged with maintaining financial stability and market integrity.

Keywords: Market microstructure, liquidity, security prices, Internet, e-finance

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1 Introduction

The Internet has had a profound and permanent impact on the trading environment, a change nothing short of revolutionary. This revolution is far from over, and if anything has been accelerated by an unusual confluence of factors in the securities industry including globalization, regulatory reforms, and technological change that has temporarily reversed a centuries old secular 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 policy makers. Faced with such 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, policy makers have a unique opportunity to shape the future. Such guidance and regulation is especially necessary at a time of market turmoil. To this end, this paper examines the impact of the Internet on equity markets, with a special focus is on market liquidity.

Liquidity is the life-blood 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.[1] 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.

We begin by discussing the key trends affecting markets today. In particular, recent changes have generally increased price volatility, a fact we document below. Nowhere is this increase in volatil-

[1] 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 (1999) show that liquidity can explain the cross-sectional variation in returns.

ity more apparent than in within day price swings. We argue that there is a fundamental inverse relation between price volatility and liquidity. Starting with volatility, we view price movements as arising 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 terms and their joint interaction, factors that have been profoundly affected by the Internet revolution. 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 trading costs. These factors have induced large numbers of retail traders to enter the market directly at a time when markets are much faster. Online traders respond to information flows in similar ways, and over increasingly short horizons. In effect, the Internet serves as a coordination device, amplifying their impact on prices. The problem is compounded by the fact that Internet investors, reacting in real time, are often unaware of the fact that their actions are mirrored by large numbers of similarly informed traders. Increasingly common episodes of market manipulation based on Internet messages are a manifestation of this phenomenon.

The overall effect of these trends has been sharply higher intraday price volatility, as we document 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 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. 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 horizon, however, the Internet's impact represents an immediate and severe challenge for regulators and policy makers charged with maintaining financial stability and market integrity, one that we explore in detail in this paper.

The paper proceeds as follows. Section 2 outlines the major trends driving the structural change in financial markets. We will focus on the US equity markets, since the changes there offer an excellent illustration of our thesis, but our conclusions are more general. Section 3 discusses how these factors exacerbate the impact of the Internet on markets and liquidity in particular. Section 4 concludes and offers recommendations for policy makers and regulators.

2 Major Trends Affecting Financial Markets

2.1 Secular Trends

It is useful to begin our 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 prevailed largely until the advent of electronic markets in the late 20th century, had to limit entry because of physical space constraints, typically operating in a mutualized governance structure. The result could be categorized as 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 US equity market. At the turn of the 19th century there were over a hundred stock exchanges in the US, in all major cities as well as isolated mining towns in the Rocky Mountains. The telegraph and telephone 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 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. 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.

2.2 Market Structure

2.2.1 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.[2] 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 in turn faster reaction times 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 prior history of non-automated operations, mutual structure is routinely avoided in favor of for-profit, joint-stock company. These changes in exchange structure increase 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 NYSE in the future. Traditional, mutualized exchanges often do

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[2] Outside the US 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

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.

2.2.2 Regulatory Change

The biggest driver in today's marketplace is regulatory change. Three major thrusts deserve emphasis: (1) Increased competition, (2) Decimalization, and (3) Transparency.

Increased Competition

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 US equity markets, this has led to heightened intermarket competition. One example is the SEC's order handling rules that opened the door for alternative trading systems (ATS) and electronic communication networks (ECNs) in 1997. Competition occurs on many dimensions: for order flow, on a global basis; for new listings, between markets. This 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 (i.e., 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), so that 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.

Decimalization

The pressure for decimalization will put pressure on exchanges to reduce the minimum price increment. If this 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

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examples are Reuters 2002 and EBS. Derivative examples include Eurex, Globex, Matif, and LIFFE. Domowitz (1993) may occur, because the reduction in minimum tick creates a disincentive to place limit orders. In turn, this means that fewer shares are offered at the prevailing bid and offer prices, reducing liquidity. 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 55 stocks to decimals is too preliminary to confirm this hypothesis, but the data is 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-sixteenths. Again, these trends favor the retail investor over the institutional trader with large volumes to trade.

Transparency

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 while other dealer markets (Nasdaq, 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 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 to placing a limit order. This effect reinforces the disadvantage of the trader with large sized orders relative to the past.

2.2.3 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 US 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.

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provides a taxonomy of automated systems.

The short-term impact of globalization on liquidity is thus to fragment the market. Eventually, we expect a consolidation of liquidity – driven by network externalities – 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, given the fragmented nature of the bond market, consolidation in fixed income appears years away.

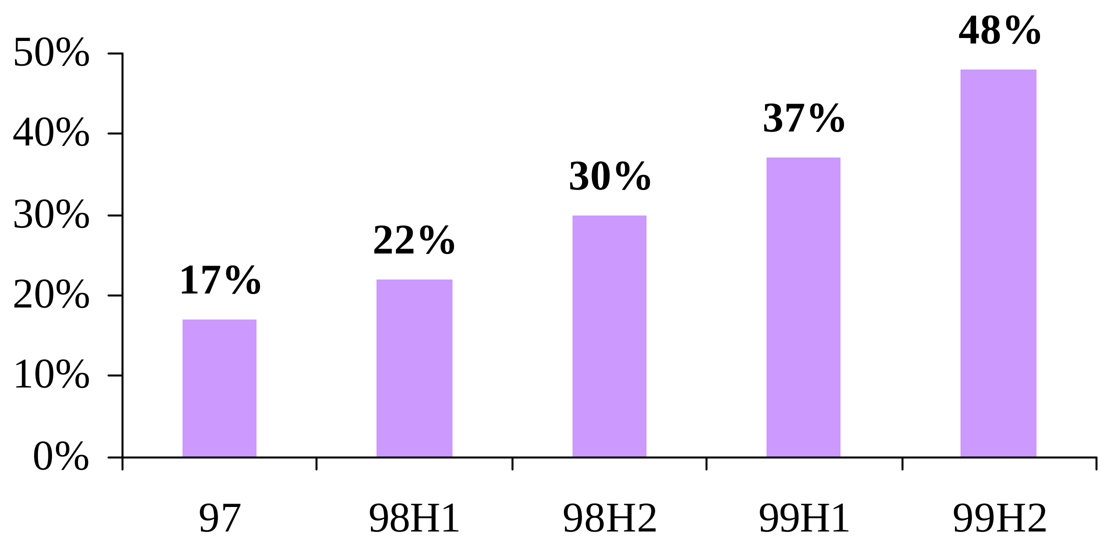
2.3 Information Structure and the Internet

Today there are about 250 million users of the Internet, of whom about 10 million are online traders. The "Democratization of Information" refers to two phenomena brought about by the Internet: (1) More information, generally of better quality, at lower or no cost, from old and new sources, is now available in real time, and (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 over a billion web pages and billions more if you count the ones below the surface covering company statements, SEC filings, business statistics, news, informed and uniformed speculation, macroeconomic information. Much of this is familiar, e.g., government sources, news, earnings forecasts and the like. Some are entirely new, purely creatures of the web, such as the information contained on message boards such as *Raging Bull or Motley* Fool, or whisper number forecasts on sites like TheWhisperNumber.com.

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 has categorized virtually all securities markets until the late 20th 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 online trading, shown in figure 1 below.

Figure 1: Online Trading as a Percentage of Retail Trades



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 to common sources of news, in real-time.

3 Implications for Volatility and Liquidity

3.1 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! website 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 on Amazon.com in a leading financial newspaper. Investors read the original story, but many others hear about it second hand through various sources. All react to it, and react quickly. The result can be a wild swing in the stock price that occurs because each investor thinks they are among the first to see and act on the news. The source of this problem is that an individual investor does not know: (1) How many other people see the same news, (2) How many of them are responding to this news, and (3) How aggressively others respond to the news. In a statistical sense, the outcome of this uncertainty is over- or under-reaction of prices to new information.

Recent advances in behavioral finance suggest the typical reaction, at least for individuals, is over-reaction, not under-reaction. Specifically, there are strong evolutionary pressures for individuals to be over-confident in their assessment of a situation, and psychological studies dating back to the 1950s confirm this prediction. Over-confidence leads to volumes that are larger than we would expect, leading to 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 they commit to posting a bid or offer in an automated system. Higher volatility thins out the limit order book, creating holes that imply lower liquidity. Evidence on this subject is provided by Coppejans, Domowitz, and Madhavan (2000) in the context of their study of the price dynamics in an automated market.

3.2 A Formalization

What is the impact of this coordination problem? Consider a prototypical market microstructure model where price changes reflect changes in consensus beliefs, Δv, and microstructure frictions. We model the microstructure frictions as proportional to the signed order flow, Δx, where the constant of proportionality, λ, is interpreted as the price impact coefficient. Formally, we write:

$$\Delta p = \Delta v + l\,\Delta x$$

Observe that market depth in this model is $1/\lambda$, i.e., 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, we write:

$$s^2(\Delta p) = s^2(\Delta v) + l^2 s^2(\Delta x) + 2\,l\,s\,(\Delta v, \Delta x)$$

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 online traders, since larger numbers of traders leads to larger volumes in general,

2. Increasing in the common response of these traders to an information signal, since 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. Why? Because limit orders are free options to the market, whose value goes up with volatility. The result is lowered liquidity, as we explain in detail below.

3.3 A Manifestation: Market Manipulations on the Internet

An example of the impact of the Internet as a coordinating device is the overt manipulation using stock chat rooms. Cyber-manipulations using message boards are a pure Internet phenomenon.

The Internet provides natural advantages to the manipulator of 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. Examples include Raytheon, Pairgain, Franklin, HealthSouth, COHO Energy, Ascend, Lucent Technologies, and many others, as discussed by Leinweber and Madhavan (2000).

A typical case is that of Aastorm Biosciences. In February 2000, hackers posted a fake message about a merger between Aastorm Biosciences Inc. (ASTM) and Gerno Corp that stated that the merger price would be $11.79 per share for ASTM, which was traded at about $4. The stock soared, trading for up to $7.50 while Gerno jumped 26% to a 52-week high of $59.625, before the fraud was discovered. These cases are not confined to the smaller capitalization stocks, but 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.

3.4 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 within day volatility. Consider the following graphs that provide a frequency distribution for the within day price range.[3]

Figure 2: Intraday Nasdaq Volatility 1996—1999

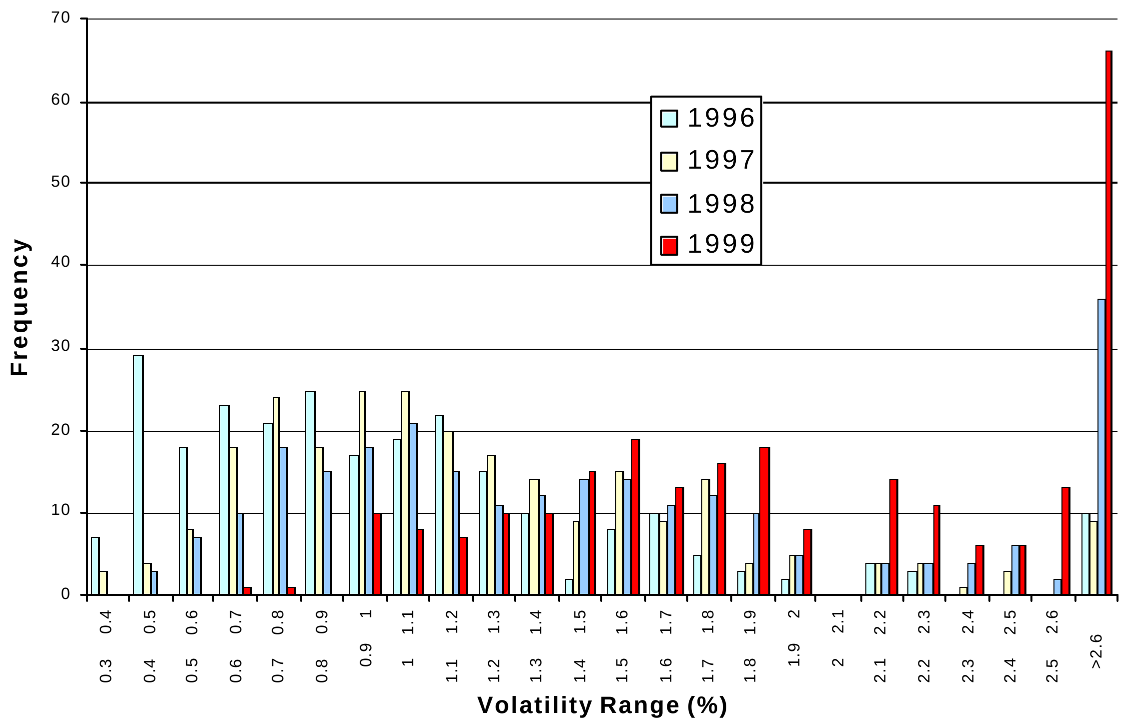
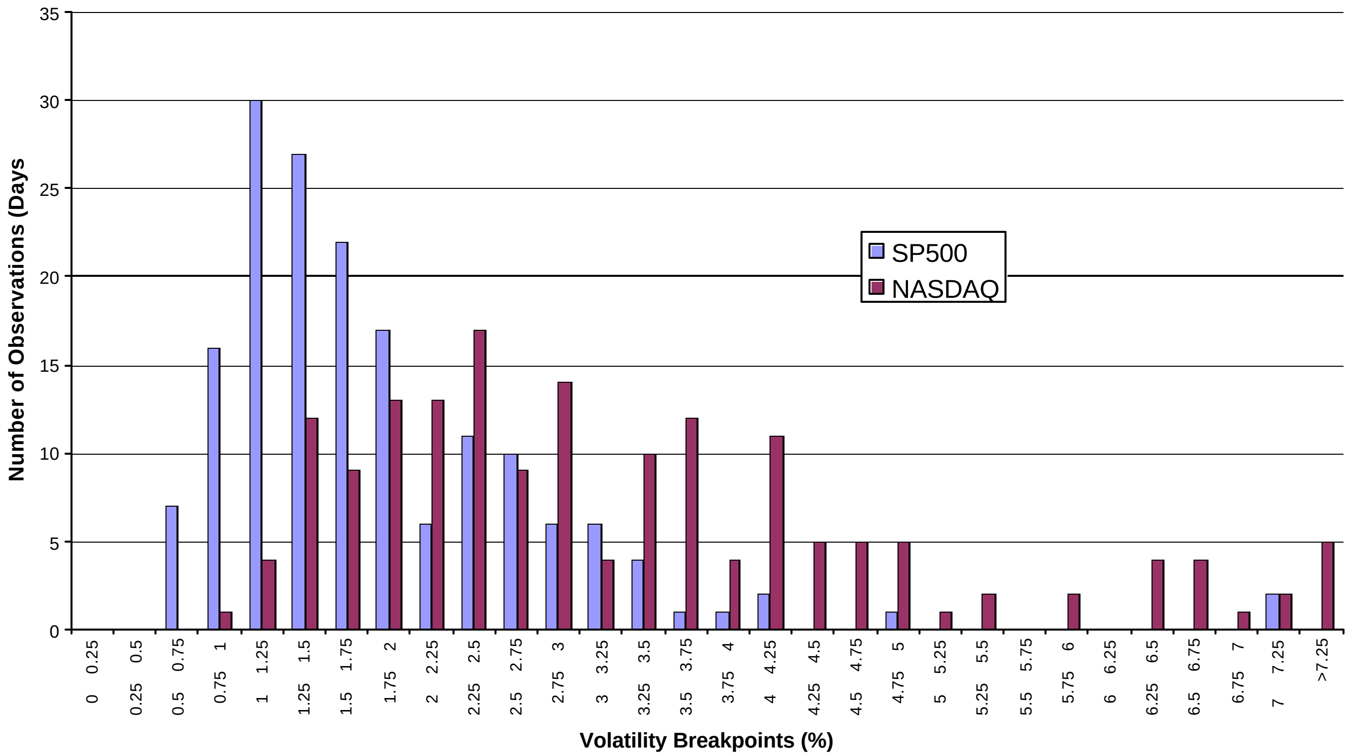


Figure 2 shows a dramatic increase in intraday volatility in 1999 relative to the previous three years. In each case, intraday volatility is defined as the intraday high price less the intraday low price, all divided by the previous day's closing price. While most commentators agree that daily volatility has been rising, the dramatic increase in intraday volatility is quite startling. In particular, observe the clustering of volatility at greater than 2.6% 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 they are typically benchmarked.

Considerable empirical evidence (Keim and Madhavan, 1998) documents a systematic positive relation between implicit trading costs and volatility. Intraday volatility is one symptom of the lack of liquidity. In the year to date 2000, the pattern has been even more pronounced as shown below in figure 3.

Figure 3: Intraday Volatility for S&P 500 and Nasdaq Stocks to September 2000



Volatility on the Nasdaq market is much greater than on the S&P 500, but both markets exhibit considerable volatility relative to figure 2. Decimalization may well worsen the short-run picture. Preliminary evidence from a variety of sources appears to confirm our 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.

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

4 Policy Issues

4.1 Adaptive Behavior by Traders and Institutions

To frame our 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. We then turn our attention to areas where some form of response is needed.

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 online 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. They need quantitative trading strategies that respond to real-time information flows and optimally allocate trades across liquidity pools, and 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, we anticipate that institutions will develop systems, products, and platforms that integrate the entire process of investment strategy and its implementation through trading. These include Smart 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 we expect 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 we expect 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 in Domowitz and Steil (1999). These arrangements are economically sensible and are technologically feasible with 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 cyber-space. The same forces that drive short-run fragmentation will result in long-run consolidation.

Over slightly longer horizons, we expect the trend toward automated auctions 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 that liquidity is quickly restored following exogenous shocks. It is likely that this high degree of resiliency reflects the fact both the index futures and underlying stocks are traded in an automated auction that makes possible efficient spot-futures arbitrage. 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, however, to say that policy responses are not required.

4.2 Policy responses

What can policy makers do to improve market quality and ensure that we develop a sound foundation for the future? I break our discussion into two parts, a discussion of regulation at the "micro" level and a "macro" discussion focusing on global integration.

At the micro-level, regulation can also improve market quality by dampening some of the volatility arising from the kinds of overt manipulation discussed above. This requires aggressive policing of the Internet and close monitoring of message boards and chat rooms in real time. The SEC, for example, now devotes considerable resources to monitoring the Internet, but most efforts to date have been reactive rather than proactive. The cases prosecuted to date involve relatively crude manipulations, and it is unclear whether more sophisticated manipulations are being detected. The aggressive prosecution of such manipulators is an important element of a regulatory response to increasing market quality.

Consistency of regulatory response is also a key factor. Uncertainty concerning the direction of future changes in regulation 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, 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 would be politically feasible. However, the exact boundaries of regulatory willingness to tolerate fragmentation have yet to be tested and remain a source of concern for market participants. A clearer definition of the future of regulation at the micro-level would facilitate the transition to a more rational market structure, not only in equities but in other asset classes as well.

At the macro-level, the pressures on liquidity identified in this article pose a more serious concern. 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, it was ultimately humbled by a worldwide liquidity crisis that adversely affected all 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 that there are explicit policies that central banks or others could do to diminish the likelihood of such events by explicit regulation or policy initiatives. 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 also requires coordination among policy makers 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 to 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.

5 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. We focus on liquidity, the crucial ingredient to price formation. We argue that an unusual confluence of technological, regulatory, and competitive factors have temporarily reversed the secular trend towards 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. Online traders respond to information flows in similar ways. In effect, the Internet serves as a coordination device, amplifying their 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 we document here. In the short-run, these phenomena represent the dark side of the Internet revolution.

Over longer horizons, 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 policy makers 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 across national boundaries.

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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 an decreasing function of liquidity because investors must be compensated for the higher transaction costs that they bear in less liquid markets. The 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 we 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

$$m^* = \frac{d}{r_f}. \tag{1}$$

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

$$m = m^* - (1 + (1 + r_f)^{-T})(l + s). \tag{2}$$

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 effect is reduced the longer the holding horizon (or the shorter the turnover), T. Similar remarks apply to a reduction in implicit trading costs or the bid-ask spread.