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Symposium on Market Microstructure: A Review of Empirical Research

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Abstract

This paper provides a review of empirical research in four topics within the area of market microstructure. Specifically, the paper provides an overview of issues related to (a) the estimation of the components of the bid-ask spread, (b) the effects of order flow characteristics and regulations on market liquidity, (c) the differences and similarities between the NYSE and the Nasdaq and (d) the interaction between the options and underlying stock markets.

Keywords: bid-ask spreads, components of spreads, order flow, Nasdaq, derivative and underlying market interactions

JEL classifications: G10/G12/G13/G14

1. Introduction

The purpose of this paper is to provide an introduction to the five articles published in this issue that were presented at the Symposium on Market Microstructure in the 1999 Eastern Finance Association Conference. Since the following articles cover a variety of topics within the area of market microstructure, we provide a brief overview of the extant literature. Our objective is to provide readers with a perspective that will help link these papers to the broad range of market microstructure issues.

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Our review focuses on empirical tests of market microstructure theories. In writing this survey we were confronted with the tradeoff between depth and breadth of material. We leaned in favor of depth. Therefore, our review does not include all branches of market microstructure, and within the areas that we cover we undoubtedly failed to cite important empirical contributions. We offer our apologies in advance to those authors.

The remainder of the paper is organized as follows. The next section provides an overview of issues related to the estimation of bid-ask spreads and spread components. Section 3 focuses on the effects of order flow properties and regulation on market liquidity. Section 4 surveys work related to the Nasdaq controversy. Section 5 reviews analyses of the interaction between options and stock markets.

2. Bid-ask spreads and the components of spread

At any point in time, the quoted bid-ask spread represents the difference between the lowest available quote to sell (the ask) and the highest available quote to buy (the bid). A trader who seeks immediacy in the execution of his order can view the spread as one component of his transaction cost. The dealer in the security provides immediacy by being willing to buy at the bid price and sell at the ask price. In this framework, dealers set the bid and ask prices symmetrically around the true price and profit from the random arrival of buy and sell orders. The spread represents a measure of the value of the liquidity service provided by the dealer (Demsetz, 1968). This model of bid-ask spreads assumes that the dealer faces only order processing costs in holding the security and there is no information asymmetry among market participants.

Generalizations of the order-processing-cost model have followed one of two approaches. In one approach, the bid-ask spread is related to the inventory holding costs faced by the dealer (the inventory models), while in the other, spreads are driven by adverse information costs faced by the dealer (the information asymmetry models).

The inventory models of the bid-ask spread focus on the costs faced by dealers who are forced to either carry long or short positions in the security that deviate from their equilibrium holdings. This deviation is caused by temporal discrepancies between market buy and sell orders and the obligation to provide liquidity in the security (Amihud and Mendelson, 1980; Garman, 1976; Ho and Stoll, 1981; Stoll, 1978a). In this framework, a dealer following the objective of maximizing expected average profit per unit of time would set spreads as a mechanism to keep his inventory at his desired level. Alternately, the dealer can be viewed as an investor who would like to diversify his holdings and has preferences regarding the risk-return profile of his portfolio. The requirements of providing liquidity in the market force the market maker to hold portfolios that are sub-optimal. Therefore, the dealer sets the bid-ask spread such that the utility gained from the dollar compensation paid to him offsets the loss in utility from the extra risk borne by holding the sub-optimal portfolio. The inventory models suggest that bid-ask spreads increase with price and the risk of the security, and decrease with trading volume and the number of market makers.

The information cost models are based on the assumption that the dealer faces two types of traders—ones that are liquidity motivated and ones that possess superior information (Bagehot, 1971; Copeland and Galai, 1983; Easley and O'Hara, 1987; Glosten and Milgrom, 1985). The dealer expects to gain from trades with the liquidity-motivated traders through the bid-ask spread. On the other hand, he expects to lose from trades with the informed traders since the latter place a buy (sell) order only if the quoted ask (bid) price is lower (higher) than their estimate of the value of the security. Therefore, the dealer optimizes his position by setting spreads that maximize the difference between the revenues earned from the trades with the liquidity-motivated traders and the expected losses from trades with the informed traders. In these models order size conveys information since informed traders prefer to trade in larger amounts at any given price. Thus, information cost models imply that trading volume should be decomposed into trading frequency and order size, as bid-ask spreads would increase with order size and decrease with trading frequency.

2.1. Estimating the components of the bid-ask spread

The above discussion suggests that bid-ask spreads are driven by three factors—order processing costs, inventory costs, and asymmetric information costs. Several techniques have been developed in the literature to measure the components of the spread. In one group of models, inferences about the bid-ask spread are made from the serial covariance of the time series of transaction prices (Choi, Salandro, and Shastri, 1988; George, Kaul, and Nimalendran, 1991; Roll, 1984; and Stoll, 1989). In the second group of models the components are inferred by relating changes in prices to transaction size and whether the trade is buyer or seller initiated (Glosten and Harris, 1988; Hasbrouck, 1988, 1991; Huang and Stoll, 1997; Madhavan, Richardson, and Roomans, 1997).

Following the discussion in Huang and Stoll (1997), the change in the fundamental value of a stock at time t ($V_t - V_{t-1}$) is determined by a combination of the private information revealed by the previous trade and public information (ε_t). Thus, the change in the fundamental value is given by:

$$\Delta V_t = V_t - V_{t-1} = \alpha \frac{S}{2} [x_{t-1} - (1-2\pi)\, x_{t-2}] + \varepsilon_t \tag{1}$$

where x_t is an trade indicator variable that takes on a value of +1 for buyer-initiated trades and −1 for seller-initiated trades, s is the constant spread, α is the proportion of the half-spread that is attributable to information asymmetry, π is probability that the trade at time t is the opposite sign of the trade at time t−1 and $(1-2\pi)x_{t-1}$ is the expected value of x_t conditional on observing x_{t-1}.

Following the argument in inventory cost models that dealers adjust bid and ask prices around the true value based on their accumulated inventory position, the bid-ask midpoint can be written as:

$$M_t = V_t + \beta \frac{s}{2} \sum_{i=1}^{t-1} x_i \quad (2)$$

where β is the proportion of the half spread attributable to inventory costs. Equations (1) and (2) imply that the change in the quoted mid-point would be:

$$\Delta M_t = M_t - M_{t-1} = (\alpha + \beta) \frac{s}{2} x_{t-1} - \alpha \frac{s}{2}(1-2\pi) x_{t-2} + \varepsilon_t \quad (3)$$

Based on the constant spread assumption, the transaction price is given by:

$$P_t = M_t + \frac{s}{2} x_t + \eta_t \quad (4)$$

Combining Equations (3) and (4) yields the basic model for revisions in transaction price:

$$\Delta P_t = \frac{s}{2} x_t + (\alpha + \beta - 1) \frac{s}{2} x_{t-1} - \alpha \frac{s}{2} (1-2\pi) x_{t-2} + \varepsilon_t + \Delta\eta_t \quad (5)$$

Estimates of the effective spread (s), the asymmetric information component (α), the inventory cost component (β), the order processing cost component ($1-\alpha-\beta$) and the probability of reversal (π) can be obtained by jointly estimating Equation (5) and the following equation for the conditional expectation of the trade indicator variable:

$$E[x_t \mid x_{t-1}] = (1-2\pi) x_{t-1} \quad (6)$$

Huang and Stoll (1997) show that Equation (5) is identical to a number of models developed in other papers. Specifically, they show that by making different assumptions about α, β and π, one can generate the Choi, Salandro, and Shastri (1988), George, Kaul, and Nimalendran (1991), Glosten and Harris (1988), Madhavan, Richardson, and Roomans (1997), Roll (1984) and Stoll (1989) models.

Empirical estimates of the magnitude of the components of spread vary considerably across different papers. For example, Stoll (1989) finds order processing costs account for 47% of the spread, information asymmetry costs contribute to 43% of the spread with the remaining 10% attributable to inventory costs for a sample of Nasdaq NMS stocks.[1] Madhavan, Richardson, and Roomans (1997) report similar numbers for the information asymmetry component of spreads for a sample of 274 NYSE stocks. Specifically, they find that this component varies from 36% to 51% over the day, with the average being approximately 40.[2] In contrast, George,

[1] As pointed out in Huang and Stoll (1997), the decomposition into order processing and inventory costs in Stoll is ad hoc and should, therefore, be interpreted with care.

[2] George, Kaul, and Nimalendran (1991) and Madhavan, Richardson, and Roomans (1997) assume that inventory costs are zero.

Kaul, and Roomans (1991) find that the asymmetric information component varies from 8% to 13% of the spread for a sample of Nasdaq NMS stocks. Huang and Stoll (1997) report similar results for a sample of 20 of the largest and most active NYSE stocks. They estimate that asymmetric information costs account for 9.6% of the spread, while order processing and inventory cost attribute to 61.8% and 28.7% of the spread, respectively.

The difference in the results in Huang and Stoll (1997) and Madhavan, Richardson and Roomans (1997) can be reconciled by recognizing the fact that Huang and Stoll focus on the 20 largest and most active stocks, securities for which one would expect low levels of information asymmetry. The difference in the George, Kaul, and Nimalendran (1991) and Stoll (1989) results is more puzzling because both papers analyze Nasdaq NMS stocks. The results in George, Kaul, and Nimalendran (1991) are consistent with the fact that quotes on Nasdaq tend to be revised less frequently than in the NYSE, thus leading to lower estimates of information asymmetry costs. One possible explanation for the difference in results is provided by George, Kaul, and Nimalendran who argue that estimators based on transaction returns such as Stoll's may be biased if expected returns are time-varying and exhibit a positive autocorrelation.

3. Market liquidity and the characteristics and regulation of order flow

Order flow plays a central role in market microstructure research. Prior to the study of market microstructure, economists largely ignored the mechanism by which prices were formed, implicitly assuming that it did not affect equilibrium outcomes. Demsetz (1968), however, demonstrates that if traders demand immediate execution, and if buy and sell orders flow at unequal rates, traders must offer a price concession to entice someone to trade. Thus the flow of orders and rules affecting how they are executed can affect equilibrium price behavior. Market microstructure research, therefore, has focused on how order flow characteristics influence the cross-sectional and time-series variation of equilibrium prices, notably the bid-ask spread.

Theoretical and empirical evidence suggests that order flow affects transaction costs by altering the dealer's cost of holding inventory, and by providing signals about security value. In turn, the inventory and information effects of order flow may be influenced by the dimensions of order flow, such as the frequency of trades, trade size and the timing of trades. Further, market liquidity may be influenced by rules regulating the size of the minimum price variation, continuous trading activity, the transparency of trade, and the location of trade execution. In the sections that follow, we discuss published and unpublished empirical research that has increased our understanding of the link between order flow characteristics, regulation and transaction costs.

3.1. The inventory and information effects of order flow—the early evidence

Demsetz (1968) argues that the price concession charged for immediate transaction will be inversely related to the particular security's trading activity. In an actively traded market the dealer can correct sub-optimal inventory positions with greater speed. Therefore, in active markets, dealers are more likely to preempt limit orders (offering to buy at a price higher than best bid or sell at a price lower than the best ask), thereby lowering the average cost of immediacy. Demsetz (1968) also provides the first empirical evidence on this issue. He conducts his tests with two measures of trading activity, the number of trades from the *Francis Emory Fitch Sheets* on two different trading days, and the number of shareholders from Moody's as a proxy for the long-run trading activity. The cross-sectional regressions reveal a significant negative relation between spreads and both measures of trading activity.

Tinic (1972) and Benston and Hagerman (1974) analyze variations on the Demsetz (1968) theme. Tinic includes variables that proxy for the size, composition and risk of the specialist portfolio. He examines the spreads of 80 stocks handled by 16 specialist firms during 19 trading days in March 1969. His evidence supports the findings of Demsetz, but he also finds spreads to be positively related to the number of stocks in a specialist unit, consistent with the hypothesis that specialist firm capital constraints influence market liquidity.[3]

Benston and Hagerman (1974) also find a negative relation between spreads and trading activity. Like Demsetz, they use the number of shareholders as a proxy for the long-term trading activity of the stock. Benston and Hagerman also test whether spreads compensate market makers for conducting transactions with more informed traders (Bagehot, 1971). They use market model regressions to estimate the inventory risk of holding the security (beta), and the risk of incurring losses to insiders with superior information (the variance of the market model residuals, or unsystematic risk). They find that spreads increase with unsystematic risk and conclude that spreads compensate market makers for bearing inventory and adverse selection costs.

The early evidence on order flow and liquidity is capped by the work of Stoll. In two highly influential papers, Stoll (1978a,b) analyzes and empirically evaluates an explicit theory of dealer costs. In the largest sample to date, Stoll (1978b) obtains the closing bid and ask price for the 2,508 stocks in the Nasdaq system for six days in July 1973, and the trading volume of each dealer for each stock. With respect to order flow, Stoll finds a strong negative relation between proportional spreads and dollar volume. Stoll also examines share turnover as a cross-sectional proxy for the degree of informed trading. The evidence reveals a strong positive relation

[3] Empirical analyses of specialist firms have not been conducted until quite recently. Cao, Choe, and Hatheway (1997) and Corwin (1999) find execution costs and other measures of liquidity to vary across specialist firms. Coughenour and Deli (1999) find the nature of liquidity provision to be a function of the specialist firm's organizational form.

between proportional spreads and share turnover, consistent with the existence of an adverse selection component of transaction costs. Additionally, Stoll finds proportional spreads to be positively related to return volatility and negatively related to price and number of dealers, consistent with his inventory holding cost model.

In sum, the above studies find a significant negative relation between the cost of supplying liquidity and order flow. This negative relation is consistent with the economic intuition of Demsetz (1968) and the explicit model by Stoll (1978a). Interestingly, Stoll (1978a,b) argues and finds evidence that order flow also provides signals about adverse selection costs. Stoll foreshadows the work of Easley and O'Hara (1987) by noting that the likelihood of adverse information may be a function of trade size. The idea that order flow contains signals about adverse selection subsequently became the source of much theoretical and empirical research.

3.2. Inventory and information effects of order flow—evidence from the specialist

During the 1980's, assessments of the inventory and information effects of order flow were largely made by examining the time-series nature of trade, quote and spread behavior. As cited above, this empirical work can be roughly subdivided into the "covariance" models and the "trade indicator" models of the spread. However, researchers also began to test information and inventory theories using specialist trade, quote and inventory data, as it became available.

Madhavan and Smidt (1991, 1993) and Hasbrouck and Sofianos (1993) initiate the line of research examining specialist behavior. They employ data comprised of NYSE specialist inventory positions and their quotes. Common to both papers is the finding that specialist inventories are slow to adjust to mean levels. Madhavan and Smidt find that it takes over 49 trading days for an inventory imbalance to be reduced by 50%, on average. Hasbrouck and Sofianos also find persistent deviations from mean inventory levels, and suggest that it might be evidence of the adjustment of quotes toward time varying inventory targets. Regardless, their evidence stands in stark contrast to the perception of specialists constantly changing quotes to manage inventory. The absence of strong intraday inventory effects is puzzling, since without inventory control, dealers may deplete their capital.

Madhavan and Sofianos (1998) explain this apparent puzzle. They conduct a comprehensive cross-sectional and time-series analysis of NYSE specialist trading on 2,751 stocks during July 1993 from the NYSE specialist equity trade (SPETS) file. The cross-sectional results find specialist participation rates to decline with trade frequency, trade size, firm market capitalization, and with measures of internalization and off-exchange competition. Thus, order flow (its level and location of execution) plays an important role in determining the level of specialist participation. The time-series evidence shows that specialists participate more actively as buyers when holding short positions, and more actively as sellers when holding long positions. This suggests that specialists tend to manage their inventory imbalances through the timing and direction of their trades.

The above papers focus on specialist trade and quote changes in response to changes in adverse selection and inventory risk. Kavajecz (1999) investigates whether specialists also use depth (the specialist's contribution to shares in the limit order book) to regulate market liquidity. He partitions the limit order book into shares offered by the public and shares offered by the specialist. He finds that specialists protect themselves from adverse selection by reducing depth around information events (similar to the changes in total depth documented by Lee, Mucklow, and Ready, 1993). Furthermore, he finds that specialist's tend to be more willing to buy (by offering shares at the bid) when prices were rising the previous hour, and more willing to sell (by offering shares at the ask) when prices were falling the previous hour. This evidence, along with that reported by Chung, Van Ness, and Van Ness (1999) suggest that specialists often stabilize prices with their trades (act as the trader of last resort).

More recently, Kavajecz and Odders-White (1999) examine the determinants of the four elements in the specialist's posted price schedule (bid price, ask price, bid depth and ask depth). They estimate the determinants using a 4-equation simultaneous system that allows for feedback effects between quotes and depth. Specifically, they examine if specialists revise their posted price schedule in response to transactions, changes in the prices and quantities offered in the limit order book (at the best and near prices), cumulative order placement and cancellation since the last price schedule revision, specialist's inventory, and competing quotes from other exchanges. They find that changes in the best bid and ask prices (and their quantities) on the limit order book have the most significant statistical and economic impact on the specialist's posted price schedule. They conclude that specialists respond primarily to information in the limit order book and that transactions and other activity play a relatively minor role. Ready (1999) also finds that specialists learn from order flow. He finds that specialists also use ''stops'' to delay the execution of an order so that incoming order flow can be used to ascertain whether they will offer price improvement.

The increasingly detailed empirical examination of specialist behavior reviewed above provides evidence that specialists use order flow to update their beliefs about security value. Overall, the evidence also suggests that information gleaned from order flow has a greater effect on subsequent spreads and depth than does specialist inventory considerations.

3.3. The information effects of trade size

As noted above, Stoll (1978a) first suggested that trade size may contain information about the likelihood of an informed trade. Easley and O'Hara (1987) extend information-based models of trade (Copeland and Galai, 1983; Glosten and Milgrom, 1985) and show that the probability of informed trade increases with trade size. One implication of this result is that larger price concessions are demanded for larger trades to compensate market makers for the increased probability of taking a loss on the trade. Their model provides a rationale to explain persistent price effects after large block trades (Kraus and Stoll, 1972; Dann, Mayers, and Raab, 1977; Holthausen, Leftwich, and Mayers, 1987, 1990).

Two branches of empirical research have addressed whether the probability of informed trade increases with trade size. The first branch focuses on the price impact of different size trades. Hasbrouck (1988, 1991) and Hausman, Lo, and MacKinlay (1992) find the price impact of trades on subsequent quotes to increase with trade size, especially for less liquid stocks. Barclay and Warner (1993) examine the proportion of a stock's cumulative price change that occurs in three trade size categories. They find that most price movement takes place on medium size trades. This evidence supports their hypothesis that if informed traders concentrate their orders in medium sizes (as found by Meulbroek, 1992), and if information is revealed through these trades, then price movements will be most closely associated with medium size trades (the 'stealth trading hypothesis'). Lin, Sanger, and Booth (1995) find the adverse selection component of effective spreads (the permanent price innovation) increases monotonically with trade size. Using limit order book data from the Paris Bourse, Biais, Hillion, and Spatt (1995) find that large trades cause quotes to change for inventory and information based reasons. For example, they find that if a large buy order uses all shares offered at the ask, this results in an increase in the ask price. But instead of immediately falling (as it should if there is only a temporary inventory effect), the bid price tends to rise as well, reflecting information in the trade. Together, this sum of research supports a positive link between trade size and the probability of informed trade.

Jones, Kaul, and Lipson (1994) initiate a second branch of related research. They decompose the trading volume of a large sample of Nasdaq stocks into trade frequency and average trade size per day. They find no relation between volatility and trade size while holding trade frequency constant. Since volatility is strongly linked to information flow (French and Roll, 1986; Barclay, Litzenberger, and Warner, 1990), and since they find no relation between trade size and volatility, they conclude that trade size conveys no information to market participants beyond the information contained in trade frequency. Using a different empirical method, Easley, Kiefer, and O'Hara (1997) estimate the information content of trade size from one stock, and arrive at a similar conclusion.

Recent working papers by Huang and Masulis (1999), Chan and Fong (1999), and Coughenour (1999), however, reconfirm the importance of trade size in the volume-volatility relation. Huang and Masulis (1999) argue that Jones, Kaul, and Lipson (1994), who compute average trade size over a full day, unduly smooth its underlying variability and lower its information content. Consistent with that argument, they find that trade size has a stronger positive relation with volatility when aggregated over hourly periods. Chan and Fong (1999) find volatility to be most strongly associated with the frequency of medium size trades (for NYSE-listed stocks) and the frequency of maximum-sized SOES (Small Order Execution System) trades (for Nasdaq listed stocks). They also find that order imbalance (the net number of buyer and seller initiated trades) explains a substantial portion of the volatility-volume relation. Coughenour (1999) holds trade frequency constant and finds a positive (negative) relation between the relative frequency of medium (small) trades and volatility which is insensitive to inventory effects (depths and spreads) and location of trade execution. These results imply that the relative arrival rates of sized trades contain information, and that informed traders may strategically place trades to disguise their presence (Kyle, 1985; Back, 1992).

In sum, the empirical evidence supports the hypothesis that variation in order flow (trade size and frequency) explains variation in both volatility (a proxy for information flow) and the adverse selection component of the spread. The results support the theoretical implication that market makers update their beliefs, and quotes, from information contained in order flow.

3.4. Order flow and transaction cost seasonalities

Wood, McInish, and Ord (1985) and Harris (1986) find return volatility to be U-shaped across the trading day. Since volatility is a measure of risk, inventory based models of transaction costs suggest that bid-ask spreads should also be U-shaped. However, Jain and Joh (1988) and McInish and Wood (1990) report U-shaped patterns in volume. Given the previously documented negative (though cross-sectional) relation between volume and transactions costs, one would expect an inverted U-shaped intraday pattern in spreads. In the first intraday study of spreads, McInish and Wood (1992) find intraday spreads to be roughly U-shaped (they describe it as a 'reverse J-shape').

What explains these patterns? Inventory-based models (Amihud and Mendelson, 1982) argue that specialists widen their spreads in response to inventory imbalances. If imbalances accumulate during the course of trading, spreads will be larger at the close of trade. Information-based models argue that informed traders have their greatest advantage when the market first opens since price is an important source of information for uninformed liquidity traders (Foster and Viswanathan, 1990; Brock and Kleidon, 1992). Therefore, adverse selection costs should be greatest at the beginning of the day. Empirical evidence of this information effect is provided by Wei (1992), Hasbrouck (1991), Foster and Viswanathan (1993), and Lin, Sanger, and Booth (1995). Furthermore, Lin, Sanger, and Booth (1995) find that adverse selection costs decrease throughout the day for all trade sizes. Together, this research suggests that order flow is most informative in the morning, or more generally, immediately after nontrading periods.

Chung, Van Ness, and Van Ness (1999) decompose the limit order book into shares offered by limit order traders and shares offered by the specialist. They find that specialists are more active participants in the morning, and as information is reflected in prices, specialists narrow their spreads until about midday, after which time they remain stable. Since the spreads set by specialists do not tend to increase near the close of trading, their results do not support the inventory-based explanations for the U-shaped pattern. However, Bessembinder (1994), Lyons (1995), and Huang and Masulis (1999) find an increasingly strong and large inventory cost component of FX (foreign exchange) spreads as the trading day nears its close.

In sum, the intraday patterns of order flow and transaction costs indicate that information is revealed through trades, resulting in progressively smaller adverse selection costs as the day evolves. The increase in the spread during the last half-hour most likely reflects an increase in the cost (risk) of holding inventory over the upcoming nontrading period.

3.5. Order flow, liquidity and the regulation of minimum price increments

Until recently, the minimum price change increment in the United States equity markets was 1/8th of a dollar. On June 2, 1997 and June 24, 1997, the minimum price increment was lowered from 1/8th to 1/16th of a dollar for most stocks on Nasdaq and the NYSE, respectively. To date, debate continues about the impact of further "decimalization", to 1/100th of a dollar or smaller, on order flow and transaction costs. At first blush, it seems evident that minimum price increments induce artificially wide spreads, and that bid-ask spreads of many firms (especially low-priced firms) are artificially wide. However, the empirical evidence suggests that decimalization may not improve the welfare of all market participants.

Before the change in Nasdaq rules, several studies examined the effects of minimum price variations. For example, although Harris (1994) does not analyze actual reductions in market tick size, he estimates the impact of changes in minimum price variations by characterizing the relation between price levels, spreads, depth and trading volume. His evidence suggests that a smaller tick size (relative minimum price variation) may yield narrower spreads but would also result in less depth. This follows from the argument that if the price of liquidity (the spread) is lowered all else being constant, the quantity supplied (the depth) will fall.

The analysis by Harris (1994) is well supported by subsequent empirical evidence. Harris (1996, 1997a) examines the Paris Bourse and Toronto Stock Exchange and finds that smaller tick sizes discourage order exposure (the placement of limit orders) by raising the expected profits of front-running (placing an order one-tick ahead of limit orders). Bacidore (1997) and Porter and Weaver (1998) find that quoted and effective spreads generally decline after the Toronto Stock Exchange lowered the tick size on April 15, 1996. Goldstein and Kavajecz (1999) report a decrease in depth across the entire limit order book after the NYSE adopted the 1/16th minimum price increment. Finally, Jones and Lipson (1999) analyze a sample of institutional trades and find that the move to sixteenths increased trading costs as a direct result of its adverse effect on depth.

The evidence, therefore, does not unambiguously support the decimalization of prices. As always, there are tradeoffs. Although the lower price obtainable through decimalization can lower the cost of trading, particularly for small orders, the cost of executing large orders may increase, due to the adverse effect of decimalization on depth. Harris (1997b,c) provides extensive reviews of research on this topic.

3.6. Order flow, liquidity and the regulation of trading halts

Regulators and exchange officials have also considered how to put brakes on rapid decreases in market values of stocks by stopping the continuous auctions at the NYSE. Following the October 1987 stock market crash, the exchanges adopted several "circuit breakers" intended to reduce return volatility by reducing (stopping) order flow. Circuit breakers halt trading when prices move a pre-specified amount. After trading has been halted, it is reopened via a call auction after the information that (presumably) caused the price change has been revealed. Collars restrict access to computerized order submission systems. The NYSE implemented two collars through amendments to Rule 80A in July 1990. The first collar prohibits the submission of market orders through the SuperDOT order routing system when executing arbitrage program trades if the DJIA has moved by more than 50 points from the previous close. Instead the trader must submit limit or tick-sensitive orders (buying on down or zero ticks and selling on up or zero ticks). The second collar of Rule 80A is the sidecar which becomes active if the S&P 500 futures contract drops more than 12 points from the previous close. The sidecar diverts all program trading market orders for S&P 500 stocks into a file. After five minutes the NYSE pairs off buy and sell orders and submits the remaining order imbalance to the floor for execution. If the floor cannot handle the imbalance, the specialist calls a trading halt.

Do these circuit breakers improve market liquidity? Lauterbach and Ben-Zion (1993) provide a near ideal experiment. During the October 1987 crash about two-thirds of stocks stopped trading on the Tel-Aviv Stock Exchange when they reached their price limits, the remaining third continued to trade. Their tests examine whether circuit breakers dampen order imbalances and whether they moderate price swings. They find that price limit halts had no impact on the overall decline in security values, but interim volatility was dampened as the trade halt helped relieve order imbalance problems.

Overdahl and McMillan (1998) study the use of circuit breakers at the NYSE through December 1993. They find that index arbitrage activity declines approximately 67% after the sidecar rule is in effect. They also find that although the spot and futures markets remained linked, pricing deviations are eliminated less quickly. Although they find a significant decrease in intraday volatility after the circuit breaker, they also find that similar changes occur on days of large price movements before Rule 80A's adoption. Overdahl and McMillan (1998) conclude that the effect of Rule 80A is minimal. Harris (1997d) notes that empirical studies of circuit breakers lack power (due to small sample sizes) and that they have difficulty in assessing what would have happened had the circuit breaker not been in place.

Individual stock trading halts called by NYSE specialists (in consultation with a floor official) are similar to circuit breakers in that they stop trading in stocks. They are dissimilar in that they are security-specific. NYSE specialists can call trading halts to resolve severe order imbalances, and exchange officials can halt trading to wait for pending news or to disseminate news. Individual stock trading halts are relatively common. Lee, Ready, and Seguin (1994) examine 852 halts involving 449 stocks during 1988 (approximately 3.5 halts per day). Although they have substantial statistical power, they also face the comparison problem. They address this by comparing the volume and volatility after the trading halts to ''pseudohalt'' periods for the same firm. They find that volume is 230% greater and volatility is 115% greater than the activity in the pseudohalt sample. They reach the conclusion that trading halts do not reduce either volume or volatility. Their conclusion should, however, be interpreted with care since the pseudohalt sample created by matching on several characteristics cannot replicate the information uncertainty that exists during and after the actual trading halts. In a tangentially related study, Corwin (1999) provides evidence that trading halt frequency varies across specialist firms. This opens the question as to how much trading halts reflect specialist characteristics rather than market characteristics.

In sum, the effect of circuit breakers, trading halts, and price limits on market liquidity is ambiguous. Some evidence suggest that these breaks in trading may do good (Lauterbach and Ben-Zion, 1993), while others argue that they inhibit the ability to learn from order flow and increase uncertainty (Lee, Ready, and Seguin, 1994). Harris (1997d) argues that empirical work dedicated to circuit breakers does not provide much information due to a lack of relevant data and due to numerous other explanations for the trading activity that follows halts. Harris also suggests that as information processing technology becomes more advanced and order flow capacities increase, the use and effect of circuit breakers will decline in importance.

3.7. Order flow, liquidity and market transparency

The SEC holds that ''... transparency—the real time, public dissemination of trade and quote information—plays a fundamental role in the fairness and efficiency of the secondary markets'' (SEC Market 2000 Study, Chapter IV-1). Accordingly, all U.S. exchanges are required to immediately report all trade prices and volumes, and constantly update the best bid and ask prices. However, markets around the world have different trade reporting requirements. For example, trades can be reported with a 90-second delay on Nasdaq, and large trades at the London Stock Exchange (LSE) and Paris Bourse can be reported with a 90-minute delay.[4] A continuing debate is whether full, instantaneous revelation of all market making activity improves market liquidity.

[4] See Porter and Weaver (1998) for possible violations of this Nasdaq rule.

The evidence reported by Gemmill (1996) suggests that changes in the transparency of large trades on the LSE has virtually no effect on market liquidity. Gemmill examines the price effects of large trades under three different transparency regimes. From October 1986–February 1989 all trades were published immediately, similar to the NYSE. From February 1989–January 1991 trades with a market value greater than £100,000 were reported after a 24-hour delay. Since January 1991, trades greater than three times 'normal market size' (a measure of average trade size) are reported with a 90-minute delay. Gemmill finds execution cost differences but none that he can trace to variation in the reporting delay. He also finds that the speed in which prices reach their new permanent level are not altered by the reporting delay.

Empirically, since trading venues like the NYSE and Nasdaq differ on so many dimensions, it is difficult to ascertain if different degrees of transparency cause differences in trade and quote behavior. For this reason, two recent studies by Bloomfield and O'Hara (1999) and Flood, Huisman, Koedijk, and Mahieu (1999) turn to experimental economics (laboratory experiments) to learn about the effects of transparency. As Glosten (1999) notes, the common finding of these papers is the idea that transparency involves trade-offs. After that, nothing else is similar. Bloomfield and O'Hara (1999) find that trade disclosure improves informational efficiency as prices arrive more quickly at their true value. The gains mostly accrue to the market makers at the expense of informed traders and non-discretionary liquidity traders. They also find that trade disclosure causes spreads to widen at the beginning of the trading round, since dealers no longer need to compete for order flow from which they can obtain information about value. In contrast, Flood, Huisman, Koedijk, and Mahieu (1999) find that spreads decrease at the beginning of trade with an increase in pre-trade quote transparency. This relation arises because, in their experimental setting, search costs arise without quote disclosure. With quote disclosure it becomes easier for dealers to trade amongst themselves which, in turn, encourages price competition.

3.8. Order flow, liquidity and the regulation of competition

In 1975, Congress ordered the SEC to alleviate restrictions that reduce competition between domestic markets. As a result, the SEC passed rule 19c-3, which lifted off-exchange trading restrictions for stocks that list after April 26, 1979. The SEC also ordered the establishment of the National Market System, including the Composite Quotation System (CQS) and the Intermarket Trading System (ITS). These systems provide real-time trade and quote information to be shared across ITS venues, which include the NYSE, Amex, NASD, and Cincinnati, Pacific, Philadelphia, Boston, and Chicago (Midwest) regional exchanges. The proliferation of information eased the access by which third market broker-dealers can enter the market of NYSE-listed securities. The intention of these regulations is to improve competition for order flow, thereby lowering the cost of transacting.

A great deal of empirical research has studied the effects of the above legislation. Demsetz (1968), Benston and Hagerman (1974) and Stoll (1978b) provide early cross-sectional evidence that spreads decrease with the number of dealers. More recently, execution costs have been shown to decrease with the number of dealers at the London Stock Exchange (Hansch, Naik, and Viswanathan, 1998), through the interbank foreign exchange market (Huang and Masulis, 1999), and through Nasdaq (Wahal 1997). Barclay, Christie, Harris, Kandel, and Schultz (1999) report that spreads of stocks trading on Nasdaq fell significantly after the implementation of recent SEC rules that allow public limit orders to compete directly with dealers.

An open question, however, is whether the market integration of NYSE-listed securities has succeeded. That is, do the positive effects of competition outweigh potential negative effects associated with fragmenting order flow away from the NYSE to OTC dealers and the regional exchanges (the ''third'' market)? Full integration may not have succeeded because some broker-dealers obtain orders through pre-arranged purchase agreements rather than by posting better prices. The order flow diverted through purchase agreements is typically referred to as ''purchased order flow''. Researchers have examined in detail the effects of purchased order flow. At issue is whether the act of purchasing order flow at $0.01 to $0.02 per share for execution inhibits competitive market making since those who buy the order flow have no incentive to offer more competitive prices.

To date, the evidence has been mixed. Early studies examined the nature of off-exchange executions. Lee (1993) uses ISSM data from 1988–1989 and finds that the price of NYSE executed trades is $0.007 to $0.01 per share more favorable than adjacent off-exchange executions. Lee notes that this figure is roughly the price of purchased order flow, a cost which broker-dealers appear to pass along to investors. Similarly, Blume and Goldstein (1997) find that the NYSE posts or matches the best displayed quote, and that quote changes are most often initiated on the NYSE. Furthermore, they find that non-NYSE markets attract order flow even when they are not matching best quotes, suggesting that payment-for-order-flow inhibits the spread reductions sought through market integration.

Hasbrouck (1995) examines the innovation variance of the random-walk component of prices as a proxy for informational changes in the efficient price. Hasbrouck examines the 30 stocks comprising the DJIA, and finds that 92.7% of the innovation variance is attributable to trades that execute at the NYSE. He concludes that price discovery takes place at the NYSE. Similarly, Easley, Kiefer, and O'Hara (1996) find trades executed on the Cincinnati Stock Exchange are less likely to be information-based compared to trades executed at the NYSE. They conclude that the evidence is consistent with ''cream-skimming'', whereby broker-dealers divert the uninformed (and most profitable) trades from the NYSE. Cream-skimming is potentially problematic, since NYSE market participants will widen spreads and lower liquidity in response to the relative increase in informed-trading at the NYSE.

Not all the evidence, however, suggests that fragmented order flow is detrimental to the liquidity of NYSE-listed securities. Battalio (1997) finds that NYSE spreads decrease after Madoff Investments (a well-known purchaser of order flow) enters the market for a particular security. Battalio, Greene, and Jennings (1997) consider the effect on market liquidity of trading rule changes on the Cincinnati and Boston Stock Exchanges that allow all their members to act as dealers (specialists). With the initiation of these rules, the proportion of order flow executed at these exchanges increases at the expense of the NYSE. They find, however, that the increase in dealer competition at the regional exchanges leads to a reduction in spreads for two-thirds of the affected stocks. Additionally, they find no evidence that any stock was adversely affected. Hansch, Naik, and Viswanathan (1998) examine trades at the London Stock Exchange and find that execution costs are the higher (lower) for preferenced (internalized) order flow relative to non-preferenced order flow. Together, these papers suggest that market fragmentation may create value for the investing public.

4. The Nasdaq controversy

In a widely publicized study, Christie and Schultz (1994) find that bid prices, ask prices and the bid-ask spread in the Nasdaq market are typically posted on even eighths in contrast to the NYSE where they are more often quoted in odd-eighths. The lower frequency of odd eighths quotes on the Nasdaq is also accompanied by wider spreads and less frequent quote revisions. Christie and Schultz (1994) suggest that collusion among market makers may account for these results. In a follow-up to Christie and Schultz (1994), Christie, Harris, and Schultz (1994) find that dealers started using odd-eight quotes for four of the largest Nasdaq stocks when the findings of Christie and Schultz (1994), became public.

Huang and Stoll (1996) argue that it is difficult to conclude that spreads on the Nasdaq are too large as compared to the NYSE since Christie and Schultz (1994) do not directly compare the two systems. Bessembinder and Kaufman (1997) and Huang and Stoll (1996) reexamine this issue by comparing trade execution costs for Nasdaq stocks with similar NYSE stocks. They report that trade execution costs are higher for Nasdaq as compared to NYSE and that these higher costs are not attributable to higher information asymmetry costs. Doran, Lehn, and Shastri (1999) report similar results for a sample of 19c-3 stocks.

Bessembinder (1997) provides some additional evidence in support of the Christie and Schultz (1994) collusion hypothesis. He finds that execution costs (measured by either the quoted or effective half-spread) on both the Nasdaq and the NYSE are related to the proportion of transactions and quotes that are rounded to even eighths. On the other hand, after making adjustments for asymmetric information costs, the relation disappears for the NYSE but persists for the Nasdaq. This implies that the higher execution costs can be justified by higher market making costs for the NYSE but that does not hold true for Nasdaq.

Barclay (1997) also reports evidence in support of Christie and Schultz (1994). Like Christie and Huang (1994), he finds that spreads decline when securities listed on the Nasdaq move to the Amex or NYSE. In addition, he finds that the decline is more dramatic for stocks where Nasdaq market makers avoid odd-eight quotes.

Grossman, Miller, Fischel, Cone, and Ross (1995) and Kleidon and Willig (1995) criticize Christie and Schultz (1994) on the basis that collusion in the Nasdaq would be infeasible given the presence of multiple dealers and the absence of barriers to entry. As an alternative explanation for the Christie and Schultz (1994) results, they suggest that even though spreads may be large on the Nasdaq, they are justifiable because of the structure of the Nasdaq market that makes the economic cost of market making greater.

Along a similar vein, Demsetz (1997) argues that at least part of the excess of the Nasdaq spread over the NYSE spread can be explained by the different methods that are used by the NYSE and the Nasdaq to handle limit orders. Specifically, Demsetz suggests that one explanation for the spread difference is that the NYSE makes the best price available to the general public regardless of its source, while the Nasdaq treats limit orders as offers to deal with the market makers.

Another explanation for the Christie and Schultz (1994) and other related results is provided by Godek (1996). Godek argues that brokers and market makers on the Nasdaq are allowed to preference an order to any market maker who has agreed in advance to execute the order at the best quoted price regardless of the price quoted by that particular market maker. As a result, the incentive for the market maker to narrow the quoted spread is reduced and one would observe larger spreads on the Nasdaq as compared to markets in which such trading is not allowed. Bloomfield and O'Hara (1999) examine the impact of order preferencing in laboratory financial markets. They find that increasing the percentage of order flow that is preferenced increases bid-ask spreads. On the other hand, if markets are already competitive, they find that allowing some preferencing does not have deleterious effects on the spread. This result receives empirical support from Battalio, Greene, and Jennings (1997) who report no negative effects surrounding the introduction of preferencing in the Boston and Cincinnati Stock Exchanges.

Yet another potential explanation for the wider spreads in Nasdaq is found in Chordia and Subrahmanyam (1995), Dutta and Madhavan (1997), and Kandel and Marx (1997, 1999) who show that discrete price increments could result in bid-ask spreads in a multiple dealer market that exceed competitive levels.

It has also been suggested that the wider spreads in Nasdaq are a result of the existence of SOES bandits. SOES bandits are investors who attempt to profit from short term price moves by executing trades through the Nasdaq Small Order Execution System. Harris and Schultz (1998) report that SOES bandits trade profitably with market makers despite their informational disadvantage. It has been argued that these SOES losses have caused market makers to widen their spreads. Harris and Schultz (1997) provide some evidence that is inconsistent with this explanation for wider spreads. Specifically, they analyze the impact of a rule change in January 1994 that reduces the size of SOES orders from 1,000 shares to 500 shares and find that spreads were unaffected by the change in order size.

Barclay, Christie, Harris, Kandel, and Schultz (1999) and Bessembinder (1999) analyze the impact of January 1997 market reforms in the Nasdaq on trading costs for Nasdaq stocks. The reforms include the requirements that customer limit orders have to be displayed and superior prices quoted on proprietary trading systems have to be disseminated to investors. Barclay, Christie, Harris, Kandel, and Schultz (1999) find that quoted and effective spreads decline by approximately 30% subsequent to the implementation of the reforms. Bessembinder (1999) compares Nasdaq and NYSE execution costs after the reforms, and finds lower costs for stocks listed on the NYSE with the same economic characteristics, though the gap has narrowed over time. He finds weak evidence that the cost difference is due to quote rounding practices, and suggests the difference is most likely due to preferencing arrangements.

Doran, Lehn, and Shastri (1999) also find that spreads on the Nasdaq fall from an average of 1.58% to 1.16% in a comparison of quotes from January–June 1996 with the same period in 1998. This decrease is a result of a decrease in both the information asymmetry component and the cost of providing liquidity. On the other hand, they also report after controlling for volume, volatility and price, that the spread on the NYSE fell by a larger amount than that on the Nasdaq. The same result holds true if one looks at the effective spread. Another interesting result in Doran, Lehn, and Shastri (1999) is that in the January–June 1996 period, the information asymmetry component of the spread is higher on Nasdaq as compared to NYSE while the reverse holds true in the 1998 period.

In summary, most studies have found that spreads on the Nasdaq are higher than those on the NYSE. The evidence on the impact of the January 1997 market reforms are mixed. Although the spread on Nasdaq has decreased after January 1997, it is not clear whether these decreases are larger than the decreases in spreads on the NYSE.

5. The relation between stock and options markets

There is a considerable amount of research on the relation between trading activity in the stock market and that in the options market. Most of the literature in this area can be broken into three related strands of research—whether options listings have an impact on the underlying stock, whether option prices lead or lag underlying stock prices, and whether the level and the cost of option trading has an impact on the underlying stock. In this section, we will provide a brief review of this literature.

5.1. Options listings and the underlying stock

A number of studies have examined the effects of options listings on the market microstructure of the underlying stocks. These include Conrad (1989), Damodaran and Lin (1991), DeTemple and Jorion (1990), Fedenia and Grammatikos (1992), Kumar, Sarin, and Shastri (1998), Schultz and Zaman (1991), and Skinner (1991).

The listing of options could have a beneficial impact on the underlying market for several reasons. First, as suggested by Ross (1976) and Hakansson (1982), options can improve the efficiency of incomplete asset markets by expanding the opportunity set facing investors. This, in turn, suggests that options would reduce the volatility of the underlying stock. Second, the listing of options could have a beneficial impact on the underlying stock market by causing informed traders to migrate to the options market. In a model developed by John, Koticha, and Subrahmanyam (1993) informed traders migrate to options markets on listing of options since they view options as superior investment vehicles. This superiority of options stems from their inherent leverage, lower transaction costs, and their ability to avoid short sale restrictions on the stocks. The market microstructure effect of this reduction in the proportion of informed traders in the underlying market, would be to lower the adverse selection costs of the market maker, thereby lowering spreads and improving liquidity.

Options listing could also lower spreads and improve liquidity in the underlying market by reducing the inventory costs of the market maker since options provide a mechanism for hedging their inventory position. Finally, options could decrease information asymmetry and improve the efficiency of the underlying market by increasing the level of public information in the market. Specifically, the marginal benefit of becoming informed after the introduction of options would be greater given the superiority of options in terms of higher leverage and lower trading costs. Thus, this increase in marginal benefits should result in a greater information search by traders. In turn, this increase in public information would lower information asymmetry, lower spreads, improve liquidity, and reduce the variance of pricing errors, thereby making the underlying market more efficient.

There is also a belief in certain segments of the market and amongst regulators that derivative markets, in general, may have a destablizing effect on the underlying market. This belief, in part, stems from the argument that the existence of derivative securities allows institutional investors to take large positions in both the derivative and the underlying market to take advantage of small discrepancies in prices. This large volume of trading, in turn, may create price pressures in the underlying security and increase the volatility in the underlying market. There is also some concern that derivatives may exacerbate the volatility in the underlying market during periods of higher uncertainty like the October 1987 crash.

The results of most studies that have compared the pre-option-listing and post-option-listing microstructure characteristics of stocks find that options listings are associated with a decrease in stock volatility, bid-ask spreads, the information asymmetry component of spread, and an increase in quoted depth, trading volume, trading frequency and average transaction size. Kumar, Sarin, and Shastri (1998) report that the changes in spread and depth persist even after controlling for changes in volatility and order flow. Based on these results they conclude that options listings improve the market quality of the underlying stocks.

5.2. The lead-lag relation between stock and option markets

Some of the arguments presented in the previous section suggest that option markets would lead stock markets in price changes. One of the first papers to examine this issue was Manaster and Rendleman (1982). Using closing option and stock prices they find that option markets reflect information up to one day ahead of stock markets. In a related study, Kumar and Shastri (1990) examine the same issue using a sub-sample of non-dividend paying stocks.[5] They find no evidence to support the hypothesis that options markets lead stock markets. Bhattacharya (1987) finds that the options market leads the stock market in overnight trading. On the other hand, he reports no systematic evidence of this lead effect in intraday trading.

The previous three papers focus on whether options markets lead stock markets, but do not allow for the possibility that the reverse may hold true. Stephan and Whaley (1990) explicitly attempt to assess whether options markets lead or lag stock markets. Specifically, they generate an implied stock price series from option prices and regress current observed stock returns on lead, contemporaneous, and lagged implied stock returns and vice versa. Their results indicate that stock markets lead options market by as much as 15 minutes. In contrast, Chan, Chung, and Johnson (1993) find no lead-lag effects if the analysis is based on quotes rather than trades. They suggest that this differentiation is important since small stock price changes may not be reflected in option prices because of the difference in the relative tick size in the two markets. Finucane and Van Inwegen (1995) suggest that previous studies suffer from the problem that they used fixed time intervals to estimate returns in the two markets. They argue that the use of fixed time intervals can bias results if trading intensity varies within a day. Using a sampling methodology that adjusts for trading intensity, they find that the stock market leads the option market by as much as six minutes.

5.3. The existence of options and the characteristics of the underlying stocks

A number of studies have examined the relation between the existence of options markets and the behavior of stock prices. The focus in this research has been on whether (a) the expiration of options have an impact on the dynamics of the underlying stock market, (b) the existence of options affect the speed with which stock markets adjust to new information, (c) changes in option trading costs affect the microstructure characteristics of the stocks, and (d) whether stock characteristics change with option trading intensity.

Option expirations may have an impact on the underlying stock either if the expiration of the option position requires a simultaneous unwinding of a related

[5] They focus on this group of stocks since they argue that the Manaster and Rendleman (1982) results may be driven by the fact that they fail to properly control for dividend effects.

position in the underlying or if exercise of the options causes a temporary excess supply or demand for the underlying. Specifically, Stoll and Whaley (1987) analyze the behavior of stock trading volume and volatility in the last hour of trading on triple-witching Fridays. They find that trading volume and volatility are higher than normal in this hour, and attribute the result to higher levels of program trading.

There are a number of reasons why the existence of options markets and the intensity of trading in options may affect underlying stock price dynamics even though an option is a derivative security whose price should be dictated unilaterally by the underlying stock price. Specifically, as argued by Easley, O'Hara, and Srinivas (1998), this unidirectional linkage between options and underlying stock prices is only valid in complete markets. On the other hand, if information is impounded into prices by trading, then the ability of informed traders to transact in option markets would imply that the option trading process is not redundant. Similarly, Back (1992) argues that trades in options and underlying assets convey different information. This implies that option trading can affect the underlying security price because it changes how information is revealed in prices and trading volume. More recently, Kraus and Smith (1996) suggest that trading in options can alter the equilibrium in the market for the underlying security either by reducing the information asymmetry in the market or by allowing investors to conjecture additional uncertainty about the future price of the underlying security. These arguments receive support from empirical studies. Specifically, Blume, Easley, and O'Hara (1994) show that trading volume provides information about information quality that cannot be deduced from prices. This would suggest that trading volume in options could provide information about prices in the underlying security.

Another possible reason for the existence of a relation between the two markets is suggested in Nandi (1994). Specifically, Nandi argues that there is a relation between trading in options markets and private information about stock volatility, with higher levels of options trading activity indicating less private information. In this framework, option trading intensity would affect stock price behavior because it provides information on the uncertainty regarding volatility estimates.

Along a similar vein, as argued previously, John, Koticha, and Subrahmanyam (1993) suggest that informed traders would prefer trading in options given the advantages of a position in a derivative over that in an underlying stock. These advantages stem from the inherent leverage in an option position, the lower transaction costs associated with establishing an option position and the fact that one can take a bearish position in an option without being subject to the short sale restrictions that exist on the underlying stock.

Finally, arbitrage links that exist across derivative and underlying markets should result in the transmission of price changes from one market to the other. Thus, because of interconnection among markets, trading activity in the options market should affect the market microstructure of the underlying stock.

The argument that options provide a venue for information-based trading receives empirical support from a number of studies. Jennings and Starks (1986) find that stock prices adjust faster to earnings announcements if the stock has listed options. Along a similar vein, Amin and Lee (1994) show that option trades lead trades in the underlying stock during periods of earnings news dissemination. This suggests that option trading activity has an impact on the price dynamics of the underlying stock through its effect on the level of information asymmetry in the stock. Mayhew, Sarin, and Shastri (1995) find that decreases in equity-option margin requirements are associated with increases in bid-ask spreads and trade informativeness and a decrease in depth for the underlying stocks. Easley, O'Hara, and Srinivas (1998) show that option volume contains information about future stock prices.

Perhaps the most direct evidence on the impact of option trading intensity on the underlying stock is provided by Mayhew, Sarin, and Shastri (1999). They find that the market for the underlying stock is more liquid when options trade. Specifically, they report that bid-ask spreads are lower and market depth is higher in periods of option trading. They also find that spreads (depth) for the underlying stock is negatively (positively) related to option volume.

To summarize, the results of most studies on the relation between stock and option markets suggest that options markets have a beneficial impact on the underlying stock market and that options trading has an impact on the information flow to the market.

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