MARKET RULES AND ORDER STRATEGIES IN THE PREOPENING, OPENING

AND TRADING DAY

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1. Introduction

A central aspect of financial trading by investors is the
determination of their order strategies, which play an important
role in forming the market's equilibrium. Obviously, investor order
strategies are sensitive to the trading environment, especially the
(1) market mechanism and trading rules and (2) the information and
trading opportunities of the investor and other traders in the
marketplace. On the one hand, the overall order strategies of
investors are influenced by the trading rules for the pre-opening,
opening and trading day. In many markets orders during the trading
day participate in a discriminatory auction as limit order
investors are executed at the prices of their orders provided they
receive execution, while opening prices are set by a uniform-price
auction in which the investor pays the price that clears the market
rather than that of his own order. Of course, more broadly the
market rules vary among the world's financial markets. On the other
hand, an investor's order execution strategy is influenced by his
information, desire for liquidity (such as the size of his order
and degree of impatience) and perception of the trading environment
(e.g., the degree of adverse selection in the marketplace and the
extent of liquidity available).

The investor's order strategy and the overall trading
equilibrium reflect the uncertainty of the market's valuation of

the security and the importance of price discovery, concerns about adverse selection (both with respect to fundamental information and order flows) and the opportunity of the investor to be strategic with respect to his own information signals and trading plans. The market folk wisdom that financial markets are "competitive" and that investors can "take" prices as given does not reflect the frictions of the trading process. Sophisticated investors do not use blind or completely random execution strategies. For example, Harris and Hasbrouck [1996, Table 5] show that in many circumstances New York Stock Exchange (NYSE) investors can do substantially better than "market" orders that do not restrict the price at which execution can be obtained. While the competitive paradigm is a good description of the determination of the value of individual securities, the short-term dynamics of trading prices reflect the dynamics of the instantaneous matching of supply and demand from the relatively small numbers of investors, who are trading the individual asset at a given point in time. The strategic opportunities of investors are greatest when considerable price discovery is needed, i.e., when the underlying valuation is quite uncertain.

2. Fundamental Determinants of Investor Order Strategy

Among the principal issues confronting investors in placing orders in financial markets are the uncertainty about the value of the underlying asset, the desire for liquidity, fear of adverse

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selection at the time their order is executed, and the desire to optimize the investor's strategic opportunities. Uncertainty about the value of the asset is especially large overnight due to the absence of trading and the substantial opportunity for fundamental uncertainty to evolve overnight (including market signals from other markets whose value is correlated). While the value of an asset would be most uncertain prior to the market opening, orders in the preopening can convey information, especially during the last few minutes prior to the opening (this is documented by Biais, Hillion and Spatt [1998] for the explicit preopening for the electronic limit order market in Paris). While investors may find it advantageous to engage in manipulative strategies during the preopening, the latter stages of the preopening and the opening itself contribute greatly to price discovery. The speed of adjustment to the asset's fundamental value is quite rapid toward the end of the preopening, the root mean square error declines substantially then (see Figure 4 of Biais, Hillion and Spatt [1998]) and the indicative prices in the latter stages of the preopening are unbiased predictors of the future (fundamental) value of the asset (see Figure 3 of Biais, Hillion and Spatt [1998]). To the extent that investors desire to participate in the opening of trade and potentially satisfy some of their desired portfolio adjustments at that point, there is a "deadline effect" that leads to transmission of orders and revelation of information towards the end of the preopening. If investors wait too long there is a risk that they will miss the opening market. That

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communication breakdown risk accelerates orders at the end of the bargaining process has been analyzed theoretically by Ma and Manove [1993] and experimentally by Roth, Murnighan and Schoumaker [1988].

Considerable price discovery and information content in the preopening in Nasdaq also is found by Cao, Ghysels and Hatheway [1998]. They find that about 17% of the daily price change is associated with the preopening and that about 35% of the time the preopening quotes are locked, i.e., the bid exceeds the ask. This is interpreted as a way for the dealers to communicate about the direction of price change in the security. In fact, during the trading day the quotes are almost never locked.

More generally, the investor's desire for liquidity (both the extent of patience and the number of shares being sought) as well as his information influence his order strategy. Investors will be anxious to trade securities when the market is relatively liquid/deep (leading to concentration of trade along the lines of Admati and Pfleiderer [1988] and Pagano [1989]) so that the anticipated execution costs are relatively limited. In a liquid market the investor can trade reasonable size orders with only a small impact on the market price. The desire for liquidity induces some trade in the opening mechanism in many markets. By spreading the investor's executions the overall market impact will be limited as less immediacy is being demanded and more opportunity occurs for liquidity providers on the other side of the market to respond.

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In some instances institutional investors who are liquidity-motivated engage in "sunshine trading" in which they preannounce their trading intentions (e.g., see Admati and Pfleiderer [1991]). Such a strategy is attractive as a way to signal to counterparties that there will be liquidity available if they soon provide orders. This occurs at the cost of placing the sunshine trader at a strategic disadvantage because he has disclosed much of his intentions (so counterparties know they can offer less favorable pricing absent strong competition). In this sense the use of a sunshine trading strategy is controversial and not employed by many liquidity-motivated traders. The case for sunshine trading is even less favorable for informed traders in that the sunshine trading strategy results in deferred execution (an informed investor will typically be anxious to trade quickly, i.e., before his information becomes available to others) and can heighten the information acquisition efforts of other investors, which would undercut the informed investor's informational advantage. Similarly, to restrict the informational flows to other investors, informed investors may find hidden orders relatively more attractive than visible orders, even though the hidden orders do not attract liquidity from counterparties.

"Participating" (percentage) orders in which an institution shares a percentage of the activity on one side of the market have become very important on the NYSE in recent years. This type of order is passive and does not require substantial execution

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expertise and judgment (though the mechanics of the order are relatively complex). The current prevalence of these orders may be a consequence of the emphasis in recent years on both evaluation of broker and trader performance and the trend towards "indexation" of institutional performance. Like sunshine trades, these participating orders are relatively patient.

An important influence upon an investor's order strategy is a desire to minimize his adverse selection costs that would result from the last mover advantage of the specialist (or other floor brokers) as well as other investors possessing private fundamental information or being able to react more quickly to changes in fundamental information or changes in the order book. Of course, these adverse selection costs can vary by the time of day and the trading mechanism selected.

3. Order Strategies and the Opening

Investors desire to adjust their own portfolio in response to information and liquidity shocks. These arise both during the trading day and overnight. Investors decide how much of their trading demand to attempt to execute at the opening of trading as compared to later in the trading day. While this reflects in part the timing of the evolution of the investor's information and liquidity circumstances, it also reflects the alternative trading mechanisms open to the investor at different times of the day.

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Overnight, i.e., while the market is closed, there is considerable production of information as companies make announcements (some intentionally deferred until the market is closed) and other markets are active. For example, the opening in the New York Stock Exchange, reflects both the general price movements overseas and the specific performance of those NYSE assets also trading overseas and the information reflected and contained in derivative pricing of NYSE assets (e.g., I can make a much better prediction about how the NYSE will open by using the S&P 500 futures pricing prior to the NYSE's open than by using the previous close).

From the perspective of responding to information available to the investor overnight about both liquidity and fundamentals and for efficiently addressing some of the investor's overall trading needs, it is natural for some of the investor's anticipated trading demands to be resolved through the opening market. However, the limited liquidity available at the opening relative to the total supply of liquidity available throughout the day should limit the extent to which the investor trades at the opening. Though this is related to the intuition in Admati and Pfleiderer (1988) and Pagano (1989) that liquidity attracts liquidity, it instead emphasizes the limits to full concentration of trade. For investors to trade too aggressively at the open would heighten their overall price impact. On the other hand, investors have a natural interest in satisfying a portion of their trading demand at the opening of the market.

Of course, the split between the opening and intraday trading may depend upon a variety of factors (which differ across markets). For example, the natural evolution of fundamental information and information generated from related markets (e.g., overseas or derivative markets) that had been open for trading will differ across markets and assets. The impact of American market price innovations on Asian assets need not match the impact of Asian market price innovations on American assets. Also the less actively traded stocks will tend to open later and also have larger spreads during the trading day, which would suggest a relatively greater proportion of their volume and aggregation occurs during the opening. These various factors makes it difficult to attribute differences in the proportion of overall trading volume that occur at the opening solely to the differences in the opening mechanism. Similarly, differences in the overnight (as compared to trading day) volatility among markets may reflect the timing of the fundamental evolution of volatility rather than simple differences in the trading mechanism. Nevertheless, cross-sectional differences in opening volume and volatility within a mechanism and the comparison across mechanisms may be helpful in understanding the impact of the mechanism on trading.

Stoll and Whaley [1990] present evidence that the open-to-open volatility is significantly larger than the close-to-close volatility on the NYSE and that consequently, the overnight innovations in returns are partially reversed during the trading

day. They interpret this evidence as suggesting that the specialist exercises his monopoly power in setting the opening price, just as bid-ask bounce generated by a monopoly specialist during the trading day also generates negative correlation and partial reversals in transaction returns.

Recent evidence due to Gerety and Mulherin [1994] suggests that transitory volatility declines throughout the trading day on the NYSE, reflecting the nature of price discovery. They interpret their results as suggesting the Stoll and Whaley [1990] evidence of greater open-to-open compared to close-to-close is not due to the specifics of the opening mechanism. I am not sure I agree with this precise interpretation since the Gerety and Mulherin findings are based upon index rather than individual stock returns (and the Stoll and Whaley argument would lead only to a slight impact upon open-to-open volatility when measured by index data). I also wonder whether the continuation of transitory volatility after the opening on the NYSE suggests that its design at the opening does not do a good job of aggregating information. The Gerety and Mulherin [1994] evidence raises the question of how price discovery during the trading day differs across markets with different designs.

Madhavan and Panchapagesan [1998] suggests that the specialist on the NYSE contributes to price discovery at the opening. They use an interesting dataset in which they are able to examine the market maker's trading decision at the opening and its

impact upon the market-clearing price. Their results show that the specialist reduces the noise in the opening price, thereby contributing to price discovery.

Nevertheless, the possibility that the NYSE specialist exercises monopoly power at the opening may be impinging upon the price discovery process. An alternative mechanism in which the preopening orders were more freely disclosed and the specialist did not possess a last mover advantage might contribute incrementally to the efficiency of market pricing [note: While the NYSE discloses the opening order information to floor traders who inquire, such queries are costly and inherently restricted to a limited set of potential traders. If the opening price is anticipated to change from the prior close by more than $.25 in either direction, then the specialist gives a preopening indication of a price range to the brokers three minutes prior to the opening. If the opening price is anticipated to change by at least $2 from the prior close, then the opening is delayed by at least ten minutes and the halt and pricing indication are disseminated to news services. The limited electronic dissemination of information during the preopening can be construed as contributing to the monopoly power of the specialist at the opening on the NYSE.] Further, investors may be discouraged from using the opening due to concerns about the last mover advantage of the specialist. Consequently, the liquidity available at the opening of the NYSE may be less than alternative mechanisms could produce. NYSE investors may internalize these

observations, by restricting their execution at the opening to limit price impact due to insufficient liquidity or adverse selection. More broadly, investor order strategies at the opening are strongly influenced by the market's design (is there a monopoly marketmaker with a last mover advantage?, are order imbalances widely disseminated in a timely manner so that the opening is relatively transparent?, how does the form of the trading rules at the opening compare to those during the trading day?).

4. Order Strategies During the Trading Day

4.1 Institutional Strategies on the Trading Floor

An important feature of large institutional orders is the importance of not simultaneously using multiple brokers to work the investor's position. The investor should delegate his trading decision to a "monopolist" working on his behalf so that (1) his brokers do not compete against each other and even more importantly (2) do not incorrectly signal to potential counterparties that there are multiple investors competing to buy (or sell) the security (this would apply on electronic markets as well as on the NYSE). Similarly, if the institutional position were being sold to a dealer who would resell the position, the dealer would require that his customer commit to not selling additional shares as the dealer worked his position (Seppi [1990] develops an adverse selection model to explain the "no bagging the street" commitment

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required by dealers). This is naturally internalized by the investor when he uses a broker to sell his block.

Institutional customers are very interested in identifying the natural counterparties for stocks that they plan to trade in order to obtain more favorable anticipated execution (e.g., less price impact) on the NYSE. For example, it would be valuable to a seller to know that the firm itself was undertaking a buyback program. In such cases the seller might direct its order to the broker representing the natural counterparty (this is a source of additional value to the broker representing a buyback order on the floor). In an electronic market or completely anonymous market, there would not be a role for such tactics.

Along different dimensions recent evidence by Griffiths, Smith, Turnbull and White [1998] points to another interesting distinction in the order strategies between anonymous markets and a trading floor. They examine the situation when the trading floor in Toronto was replaced with an electronic system and find much stronger evidence of imitative order behavior in the floor trading case, which they associate with the brokers exploiting their ability to identify and imitate certain specific traders.

4.2 The Language of Orders

Another important aspect of an investor's order is the price

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limit specified by the investor. This determines the aggressiveness of the investor's response to investors trading on the opposite side of the security in question.

In an electronic trading system (such as the Paris Bourse) the investor's order (e.g., bidding) strategy stands in the market until it is revised by the investor. In a marketplace such as the NYSE in which larger orders (and most of the share volume) are typically handled by floor brokers, delegation is important. The standard datasets that capture orders (e.g., the TORQ) do not include these orders. We would expect that for these larger orders the investors would avail themselves of the flexibility to give their floor brokers discretion based upon information available on the trading floor. Nevertheless, it is important for investors to communicate their eagerness to trade (time frame and perhaps pricing) and the scale of their desired trade to their floor broker so that he can respond to available opportunities.

Though retail customers also can provide similar indications of their own eagerness to trade to their own broker, the message space available is not rich enough for these to be communicated to the trading floor. For example, if the retail customer communicates to the trading floor an order to buy shares with a certain maximum price, then the order will be posted as a limit order at that price (and typically executed at that level, if at all). Similarly, an unrestricted retail order to obtain the best possible (but certain)

execution is often expressed as a market order. Notice that the market order does not result in the best expected execution, but certain execution in the near future (e.g., Harris and Hasbrouck [1996]). While a market order for a size that does not exceed that being offered at the prevailing quote seems equivalent to a limit order at that price, the practice on the NYSE makes these orders subtly different. Specifically, the limit order at that price is directly executed against the liquidity which is immediately available at that price in the limit order book, while in some cases the specialist will "stop" the market order (guaranteeing execution at the same limit price) and try to obtain price improvement for it [note: For example, Harris and Hasbrouck [1996, Table 5] includes some evidence of the differential performance of "marketable" limit orders and market orders conditional on order size, but not the amount of liquidity available at the quote.]

The stopping of orders need not be viewed as benevolent behavior by the specialist as he can only trade on the NYSE by improving the price in the limit order book. Rather than immediately bettering the price, in many cases the specialist would prefer to stop the order and observe subsequent market conditions before undertaking the execution at the improved price (at the cost of losing the trade for the specialist's account when other investors arrive to compete). The price improvement obtained from a "stopped" order comes at the expense of the public limit order book, reducing the value of placing limit orders and the extent of

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competition experienced by the specialist. This behavior by the market maker is a way to reinforce "the time and place" or adverse selection advantage he possesses as compared to public limit order investors and discourages competition by limit order investors.

4.3 Order Strategies and the Order Book

In many cases expected execution can be improved relative to either a market order or a "marketable" limit order that would execute against the prevailing quote, as Harris and Hasbrouck [1996] document. For example, when the NYSE minimum grid size was 1/8 they show that expected execution can be improved for stocks with a 1/4 spread by placing an order at a limit price at an 1/8 better price (i.e., inside the spread) to attract liquidity providers who are willing to beat the quote on the opposite side of the market (see Table 5 in Harris and Hasbrouck [1996]).

While Harris and Hasbrouck [1996] focused upon the performance of alternative strategies in the NYSE, Biais, Hillion and Spatt [1995a] examine the conditional frequencies of different strategies in the electronic limit order book in Paris [note: Harris and Hasbrouck [1996, Table 3] also include some summary statistics on order frequencies and observe that in their dataset the most commonly used limit order tends to be the best performing order]. Consistent with the findings of Harris and Hasbrouck [1996], Biais, Hillion and Spatt [1995a, Table V] find that when the spread is

relatively wide liquidity is often supplied (limit order suppliers beat the existing quote), while when the spread is relatively narrow, the liquidity providers are more willing to accept the prevailing liquidity, which is being offered on relatively favorable terms. Parlour [1998] shows theoretically that the buying and selling dynamics are intertwined. Biais, Hillion and Spatt [1995a] observe that since the liquidity of the market on the buying and selling sides are not identical, liquidity considerations should influence the cross-autocorrelation between buying and selling orders and lead to mean reversion in the bid-ask spread (these observations are illustrated in their Figure 3). Foucault [1997] and Parlour [1998] develop equilibrium models of endogenous order placement.

Parlour [1998] shows theoretically that when the depth provided at the quote is relatively large, then given the time priority system limit order investors possess a relatively stronger incentive to beat the quote (to jump in front of the liquidity on their own side of the market). This is illustrated by the empirical findings in Biais, Hillion and Spatt [1995a, Table V] who show that in the electronic market in Paris that the frequency with which investors undercut the prevailing quote is greatest when the quoted depth is relatively large. This reflects the adverse selection cost that confronts limit order investors. For example, Rock [1990], Glosten [1994] and Seppi [1997] analyze this adverse selection cost in settings in which the market makers can use the size of an

incoming order to decide to what extent to preempt the limit order investors (in fact, on the NYSE floor traders strongly contribute to this adverse selection since they can largely preempt the limit order investors without even undercutting them on price).

This argument suggests that the extent of the incentive to undercut the quote for a deep book is particularly great for a specialist system as compared to a pure limit order system because the specialist has a strong last mover advantage. Of course, to some degree limit order investors who have placed orders that have grown stale also will be subject to adverse selection vis-a-vis the other limit order investors in the crowd or in an electronic limit order market. Consistent with this argument, we would expect specialists to trade more actively when they do not face competition from floor traders. Sophianos and Werner [1997] document that the specialist's participation rate is almost twice as large for stocks without active floor trader participation. An important feature of the New York Stock Exchange concerning this observation is the way in which time priority operates. The time priority on the NYSE only applies to orders in the electronic book, but does not apply to the floor brokers, who are able to share the priority with the book--in fact, if there are n floor brokers, the electronic order book only receives $1/(n+1)$ of the order flow. The role of time priority enhances the sensitivity of undercutting in an electronic market with time priority as compared to the NYSE, where the role of time priority is limited. On balance, it is

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difficult to determine a priori whether the sensitivity of the order strategy to the quoted depth is relatively greater or lesser on the NYSE or a fully electronic limit order market.

As has been pointed out in a variety of studies the tick size of the market system has an important impact on time priority (e.g., Harris [1994, 1996] and Spatt and Srivastava [1994]). Time priority does not have much impact in a situation in which the tick size is small, because the cost of undercutting to jump ahead of the queue is modest. Of course, the relatively smaller tick size for low-priced stocks in Paris limits the strength of time priority there. Similarly, in a specialist system in which the specialist is required to trade behind all public orders (such as the NYSE), the cost of the specialist undercutting is reduced with reductions in the tick size. Therefore, I expect that specialist participation rates rose dramatically last year after the reduction in tick size on the NYSE. At the margin, this effect should make limit orders less attractive to provide on the NYSE and reduce the overall depth provided by the limit order book [of course, in measuring the depth of the book one should control for the greater number of grid steps available after the tightening of the grid size]. On the other hand, the disadvantage of the limit orders vis-a-vis floor brokers, who share priority with the limit order investors, is reduced with the tightening of the grid size (which might lead to differential impacts across stocks, as floor brokers are much more important for the largest and most liquid stocks). Another interesting issue is

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the impact of a reduction in tick size (and the cost of trading throughout the day) on the relative proportion of volume at the opening of the market as compared to within the trading day. An interesting way to examine these issues would be to examine these issues both cross-sectionally (as percentage tick sizes vary with the stock price, and the relative role of floor brokers is greatest for high volume stocks) and across grid size regimes. Interestingly, while the specialist's participation rate on the NYSE would be expected to increase with a tighter grid, the NYSE specialists clearly prefer a relatively wider grid. Apparently, the direct profitability of being able to trade across a wider spread exceeds its disadvantage of being costly for the specialist to undercut public investors.

An interesting phenomenon on many financial markets is the clustering of orders. While the extent of clustering may vary with the liquidity of the market, even the NYSE has considerable clustering of trades (e.g., Harris [1994]) and orders. Obviously the clustering of executions and orders is puzzling. In fact, I think it suggests a real opportunity for traders. Specifically, it may be attractive to offer liquidity at prices at which the limited order book is anticipated to be thin. As an example, round prices tend to have relatively a thick book of orders. For example, I visited the floor of the NYSE on a day last summer in which Johnson and Johnson stock was trading for 64 and a fraction. There were stop limit orders for several hundred thousand shares at 60, more

than 100,000 at 61 and 62, but little at the fractions. Clearly, a stop limit at 60 and 1/16 would be relatively more attractive if it were ahead of the queue of orders triggered when the price reached 60. Clustering suggests an apparent violation of equilibrium restrictions on the limit order book. While it does not discuss clustering per se, a related econometric approach is used in Sandas [1996] in examining the marginal (in terms of timing and time priority) break-even condition at each discrete price, finding that the liquidity supplied further from the quotes is insufficient compared to the liquidity at the quotes to satisfy the zero expected profit conditions and that changes in the order book are insufficient compared to the static structure of the order book. Clustering may be a nice way to characterize inconsistency in the limit order book. The discussion of clustering points to an interesting linkage between order strategies and trading mechanisms as a relatively more transparent system (such as an electronic limit order market as compared to the NYSE) in which clustering was easy for arbitrageurs to identify should have relatively less clustering.

4.4 Trading Rules and Order Strategies--An Example from Nasdaq

The impact of trading rules on investor order strategies is illustrated by some of the features of the Nasdaq market prior to the changes in market design during the last few years. Among the interesting features of the design of this dealer market were

dealers not displaying customer orders, dealer respecting neither time nor even price priority, and the effective use of a 1/4 point pricing grid for most Nasdaq stocks (this latter issue was at the heart of the Christie and Schultz [1994] analysis of Nasdaq). How would these features of the design influence the order strategies of investors? In light of the market design investors had little incentive to follow a strategy other than hitting the quote when there was sufficient depth at the quote to accommodate the desired position. Given the prevailing practices of the Nasdaq market makers, it was very difficult to obtain execution inside the quoted spread despite the quoted spreads appearing to be wider than those that prevailed in some other exchanges. [Note: The empirical results in Biais, Hillion and Spatt [1995a] and Harris and Hasbrouck [1996] suggest that with adequate competition investors will find it advantageous to place orders inside the quotes, when the prevailing spread is wide.] Imagine an investor placing a limit order to sell at 26.375 when the bid price is 26.25 and the ask price is 26.5. Typically, such an order would not have been displayed by the dealers (so that the dealers would not advertise the availability of a better price than the quote) and the dealers would execute their own orders ahead of the public's limit order (given the absence of price priority rules the dealers were not required to execute the public sell order at 26.375 ahead of the dealer's offer to sell at 26.5!). In fact, on some occasions the sell order at 26.375 would be filled as the quote was rising on the 1/4 grid to 26.5 bid and 26.75 offered (see Figure A), so that the

execution would actually occur at a price inferior to the bid (i.e., outside the quote), once the bid would otherwise be 26.5. If an investor finds that his order inside the prevailing bid-ask quote are never filled until the quote moves such that the order is at or outside the quote, then the investor would do better (relative to the quote and the fundamental value of the asset) using an order to simply hit the liquidity being supplied at the quote. This example provides a simple illustration of how the trading mechanism should influence the investor's order strategy. Of course, in this (Nasdaq) example the rules contained the seeds of their own ultimate destruction.

5. An Example of Order Placement: Strategic Behavior During the Preopening in Paris

Biais, Hillion and Spatt [1995b] analyze order placement in the Paris Bourse, during the preopening period (between 8:30 and 10:00), which precedes the opening call auction. Computing and interpreting descriptive statistics we obtained several preliminary results. To avoid information revelation and adverse price impact, large strategic traders wait until the end of the preopening period to place the orders they wish to get filled. However, they tend to place these orders somewhat before the very end of the preopening period, lest communication breakdown would prevent participation to the opening market for orders submitted too late. Earlier during the preopening period traders send preplay communication orders, to

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advertise their willingness to trade, and attract liquidity (in a fashion similar to sunshine trading). Also traders face a tradeoff between placing supply and demand schedules, to control execution risk, and placing single limit orders, to reduce their impact on prices.

We also anticipate that the explicit data from the preopening will shed considerable light on price formation in other markets for which there is not as explicit a preopening (such as the New York Exchange) and the comparative performance of different market structures (such as various aspects of the Paris Bourse structure compared to the New York Stock Exchange and other major international markets). Because of the explicit structure of the preopening in the Paris Bourse and the availability of order data prior to the opening, we can go inside the "black box" aspects of the opening mechanism in order to understand the process by which prices are formed. By undertaking an empirical analysis of the preopening process, we examine the incentives of the traders to participate truthfully or behave strategically in this process, and examine the efficiency of the preopening as part of the price discovery process.

This analysis will shed light on such questions as:

1. How are prices formed?

2. How do preplay communication and price discovery work empirically? Does preplay communications among traders during the

preopening period enhance price discovery? To what extent is an explicit preopening useful in facilitating improved price discovery (e.g., in light of the concentration of activity at the end of the preopening)?

3. To what extent do investors behave strategically in the preopening and how does this influence the price formation process? How do the various orders transmitted by a broker on a stock during a preopening session relate? What does this suggest about trading tactics and strategies? What is the role of order schedules during the preopening?

4. How does the temporal profile of various types of orders enhance our understanding of how deadline effects influence agent behavior and the determination of the market equilibrium (such as the interpretation of the differences in timing of various types of orders)? How do the incentives for transmission of different types of orders influence the temporal profile of these orders?

5. How are various types of order characteristics used in practice? For example, what is the relationship in the preopening between such factors as the size of an order, its pricing, its timing, whether the order is executed or canceled, whether the order is even intended to be executed (for example, if it is an aggressive order is it canceled prior to the opening?) and whether it is visible or hidden?

6. How are the market impact and adverse selection costs at the opening relative to later in the trading day influenced by the preopening process? What are the implications of our findings for

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the efficient design of securities markets in various countries? How can the operation and design of the financial markets be improved (e.g., to reduce adverse selection costs or facilitate price discovery)?

The economic hypotheses are illustrated by two examples of preopenings, in Figure 1 and Figure 2 of Biais, Hillion and Spatt [1995b]. These figures present plots of orders placed for Schneider on October 5 and 6, 1993. These two days were the most active in a pilot sample examined by Biais, Hillion and Spatt [1995b] of two stocks and 26 days.

5.1. Preplay Communication

5.1.1. Advertising

Investors who want to buy or sell shares can use the preopening period to advertise this, to attract liquidity from the other side of the market (this is one of the motives for sunshine trading, which is analyzed in Admati and Pfleiderer (1991)). This is also similar to the desire of a homeowner to advertise rather than conceal that his property is being offered for sale. For example, if the trader is a discretionary liquidity trader, as in Admati and Pfleiderer (1988), and if he desires to buy, then he can place visible orders to buy relatively early during the preopening period in order to attract the attention of sellers. A similar

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strategy would have been much less viable during the actual trading day because of the risk of execution of a large order at an unfavorable price (illustrating some of the potential usefulness of preplay communication). In order to avoid price manipulation by the other traders at his expense, the trader may withdraw his orders after some time, and then choose to enter them again (maybe in a somewhat modified form) in the last minutes before 10:00 a.m., provided he feels that market conditions are favorable.

One example of order placement which we interpret as advertising is in Biais, Hillion and Spatt's [1995b] Figure 1, Panel B. The 6 orders on top of the figure, at price 424, and denoted AD, were placed by the same broker. The first 3 of these 6 sell orders were placed relatively early and canceled before the opening. The last three were placed somewhat later (possibly after the first 3 had been canceled) and executed at the opening.

5.1.2. Testing

During the preopening period, sophisticated traders can learn about the information in the order book, by placing testing orders. Learning and testing orders are not very costly, unlike orders within the trading day, because they can be canceled before the opening and thus run no risk of being executed. Such testing can be useful because some of the information in the order book is not disseminated. The broker screens during the preopening and during

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the trading day only show the four best unexecuted quotes. More importantly, the screens only show the visible portion of the orders, not the hidden portion, even at these four price levels. To extract the information not immediately available, the traders can place large testing orders. The reaction of the indicative prices and volumes provides information on the orders in the book and can be used to estimate the supply and demand curves more accurately.

5.2. Execution Strategies

5.2.1. Execution at the opening is more attractive than later in the trading day

Because the overall amount of the daily trading that occurs at the opening is rather large, the impact of individual trades is limited. This is reminiscent of theoretical analyses where liquidity traders have incentives to trade all together (see Pagano (1989), and Admati and Pfleiderer (1988)). Further, the uniform price mechanism used at the opening limits the price impact of aggressive orders, such as high priced buy orders or low priced sell orders, in contrast with the discriminatory mechanism used during the day. The opening mechanism can be viewed as a uniform price auction because all agents trade at the same price, while the continuous market can be seen as a discriminatory mechanism since agents trade at a price depending on their order.

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Also, the uniform price auction can limit winner's curse effects, to the extent that investors do not trade at their own quote, which may reflect limited information, but at the market price, which aggregates different signals. [A somewhat related comparison of the differences in trading costs among trading mechanisms at different times of the day is in Monaco (1994).] In the somewhat different but related context of Treasury securities primary markets, Back and Zender (1993) consider an example where there is no winner's curse in a uniform auction, while the winner's curse problem is severe in the discriminatory auction. The opening may represent a relatively more attractive trading structure in Paris than on the NYSE due to the adverse selection problem at the NYSE opening described by Stoll and Whaley (1990), i.e., that the specialist moves last and benefits from special information about the aggregate order flow.

5.2.2. Large Orders Placed During the Preopening Period have an Adverse Impact on Price

Direct Price Impact

This impact can be direct, in that large orders can influence the opening price, for given orders placed by the other traders. This is similar to the static competition in schedules game analyzed by Kyle (1989).

Two examples of this direct impact of orders on price can be seen from Figure 1 and Figure 2. As can be seen on Figure 1, Panel C, the last order placed for Schneider, at 379, on October 5 was a rather large order to sell. This order acted as a price setter and drove the price down to 379 (the consequences of this order are further discussed below). Similarly, as can be seen on Figure 2, panel C, on October 6, the 3 largest orders placed during the last 10 minutes of the preopening period, were at 369, which turned out to be the opening price, due to their impact.

Indirect Price Impact

The price impact of orders can also be indirect, and result from the reaction of other market participants, generating an adverse price impact. This is similar to the theoretical analysis of price dynamics before the opening by Vives (1995), where large sales (purchases) send a negative (positive) signal, which results in a decrease (increase) in the price. However, Vives (1995) assumes competitive traders, while our empirical results below suggest that large traders behave strategically. Medrano and Vives (1998) show theoretically the potentially optimality of manipulative behavior by a large strategic informed investor in a setting in which the likelihood of the market opening gradually increases during the preopening.

5.2.3. How to Minimize the Price Impact of Orders

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Indirect Price Impact

In the end of the preopening period, the impact of orders on prices is lower because (i) other agents have less time to react and (ii) order placement by other agents is larger and thus provides some camouflage. The latter point suggests coordination effects, and is reminiscent of the analysis of Admati and Pfleiderer (1988) concerning the clustering of trades. To avoid the revelation of their willingness to trade, and thus reduce indirect price impact, traders have incentives to wait until the very last minutes of the trading period and also to place hidden orders.

Consistent with this remark, Panel A in both Figure 1 and Figure 2 shows that larger orders tend to be concentrated towards the very end of the preopening period. Further evidence is in Panel C of Figure 2, where for the 6 largest orders, we have indicated whether these were visible or hidden. As can be seen on the figure, 5 out of 6 were hidden. Similarly, in Panel C of Figure 1, 9 out of the 10 largest orders were hidden.

Direct Price Impact

To minimize their direct impact on the price, large traders possess the incentive to scale back the size of their trades and to use single orders at relatively unaggressive price levels. This is illustrated by the following stylized example. Suppose there is

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uncertainty about the opening price, or equivalently, from the point of view of a strategic seller, about the residual demand. Assume the latter can be huge, medium or low. The strategic seller has the choice between the alternative strategies of either placing a single order at a high price, or placing two orders, one at a high price and the other at a low price. If demand is huge, it does not matter what the trader does (as this is a uniform price auction) and the trader gets filled at the high price. Suppose that if demand is low, the trader obtains execution only if he has quoted a low price. Assume also that if demand is medium, and the seller has quoted a low price, the opening price will be this low price and the low price order (but not the high price order) will be filled. Finally, suppose that if demand is medium and the seller has only posted a high price order, the opening price is the high price, and the seller gets filled (maybe partially) at that price. In this stylized situation, the trader may find it optimal to quote a high price only, rather than a schedule, to avoid lowering the opening price, if there is only a small probability that demand is low. This line of reasoning is rather similar to some analyses of price discrimination (as illustrated by Chiang and Spatt (1982)).

5.2.4. There is a Trade-off between Minimizing Price Impact and Maximizing Execution Probability

Because of Deadline Effects Traders Avoid Placing Orders Too Late

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As discussed above, to minimize price impact, strategic large traders have incentives to place their orders only at the very end of the preopening period. However if they wait too long there is a risk that they will miss the market, either because of some delay in routing the order or because of some urgent event that the trader needs to address, which would prevent him from placing his order in time.

Using Single Orders Instead of Schedules Can Reduce Execution Probability

As discussed above, in order to minimize price impact, strategic traders may prefer to quote a single order rather than a schedule. However this strategy increases the risk of missing the opening market, which is costly since as noted above liquidity is relatively abundant at the opening.

An interesting illustration of this trade-off is observed for Schneider on October 5, 1993, on Panel C of Figure 1. The largest order of the day (a sell order for 10,000 shares) was placed that morning just before the end of the preopening period (at 9:59:45), very close to the money (at 380). If this order had been the last order placed during the preopening period, the opening price would have been 380 and the order would have been executed (at least partially). On the other hand, if the trader had placed a significant fraction of this order at 379, then the price would have been 379. This is consistent with our above discussion of

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large traders placing single orders to minimize price impact. However a few seconds later, just before the opening (around 9:59:55), another broker undercut this large order, with a sell order for 1000 shares (which is a rather large amount, though much lower than the 10,000 order just described). This order was the last of the preopening period, moving the opening price down to 379, so that the very large order did not get filled. This example illustrates our above statements that: (i) placing a single order rather than a schedule reduces price impact in case of execution, but (ii) increases execution risk, as by increasing the vulnerability of the order to undercutting, and (iii) large orders can have an adverse impact on price.

The example also illustrates two other economic issues mentioned above. First, in the Paris Bourse one is never sure of being the last mover of the game, which distinguishes our limit order traders from the NYSE specialist. Second, there is a deadline effect: if the very large trader offering 10,000 shares had not been concerned by the possibility of missing the opening by placing his order too late, he would have waited even later, and thus reduced the risk of being undercut.

5.3. To Reduce Execution Risk, Traders Can Use Schedules Rather Than Single Orders

As discussed above placing schedules instead of single orders

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can help traders reduce execution risk in the presence of uncertainty about the final state before execution (an example of this in a price discrimination setting is presented in Chiang and Spatt (1982)). This reduction in execution risk is likely to offset price impact for relatively small trades, and in very uncertain markets.

On Figure 2, panel C, one can observe order placement patterns which can be interpreted as schedules, occurring on October the 6th. We identify three potential schedules. The first one occurs between 9:50 and 9:51, and is composed of 5 visible sell orders placed at prices ranging between 372 and 386. The second is composed of 9 visible sell orders placed between 9:52 and 9:55 at prices ranging between 361 and 369. The third is placed around 9:57 and is composed of buy orders at prices ranging from 360 to 355. Consistent with our above discussion that large traders might prefer to avoid placing schedules, to minimize price impact, the observed schedules in Figure 2 are for relatively small quantities.

Interestingly, the first and the third schedule were placed by the same broker, on both sides of the market and somewhat away from the money. They were not filled and were canceled later. These orders can be interpreted as market making by the broker, placing schedules around the likely opening price, to benefit from possible liquidity shocks, shifting the price away from its equilibrium value. Thus, the broker would play a role similar to that of the

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specialist, analyzed by Stoll and Whaley (1990). Note that, unlike the case of the specialist, this broker has no privileged information about the order flow which other brokers would not possess. As noted above, this reduces the adverse selection problem.

The other price schedule was placed by another broker. The two lowest orders in this schedule were executed at the opening, while three others were filled later in the day. This indicates that such schedule placement strategies can enable traders to achieve rather effective execution profiles.

6. Concluding Comments

The analysis of order strategies is at an early stage, but valuable insights have been obtained by considering adverse selection, price discovery, liquidity and the strategic opportunities open to investors. The behavior of investors is driven by these considerations under a variety of alternative trading mechanisms, where the mechanisms both vary across markets and within the day.

Both theoretical and empirical analyses have shed considerable light on investor order strategies and their implications for the structure of market pricing. Existing analyses have largely focused upon order and transaction data without identifying information

about the identity of the trading firm. As more datasets become available which provide information about the identity of the brokerage firm undertaking each order, facilitating matching of investor strategies, new insights should emerge. At a methodological level, I suspect that structural estimation will prove particularly useful because the objects being estimated are directly tied to the underlying theory and the empirical analysis and theoretical framework are tightly linked. The structural estimation approach is used to study limit orders in Sandas [1996] and Hollifield, Miller and Sandas [1995]. For example, Hollifield, Miller and Sandas [1995] tests non-parametrically the restriction from the incentive compatibility constraints on the bidding behavior of the investor that the investor's limit order price is monotone is his valuation. This offers a robust approach to estimating bidding strategies. For example, in their Table 10 Hollifield, Miller and Sandas [1995] document the fraction of observed order choices (more than ten per cent) that do not satisfy monotonicity.

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TABLE 5

Mean Ex Ante Order Performance

Order Size (Shares)	Limit Price Position	Bid/Ask Spread at Time of Order Entry					
		$⅛			$¼		
		Sell	Buy	t^a	Sell	Buy	t^a
≤ 200	≤ -1/4	-1.2¢	-1.0¢	0.03	7.5¢	3.8¢	-0.47
	-⅛	0.4	2.3	0.58	5.8	4.9	-0.22
	0	4.5	4.8	0.38	8.1	7.1	-0.62
	+⅛				10.2	10.0	-0.58
	Market	1.7	1.5	-2.45	8.6	8.0	-2.49
201–500	≤ -¼	-2.1	-3.4	-0.21	0.8	0.1	-0.13
	-⅛	0.8	0.7	-0.07	4.1	4.5	0.12
	0	4.1	3.3	-0.85	7.9	6.7	-0.89
	+⅛				9.2	8.5	-1.64
	Market	1.1	1.0	-2.90	7.3	6.7	-2.75
501–1,000	≤ -¼	-2.5	-4.9	-0.41	3.5	2.4	-0.18
	-⅛	1.8	0.1	-0.80	5.1	3.2	-0.86
	0	3.1	2.2	-1.25	6.8	5.5	-1.17
	+⅛				7.7	7.2	-1.30
	Market	0.7	0.5	-2.81	6.0	5.6	-1.65
> 1,000	≤ -¼	-2.6	-4.5	-0.37	2.1	2.5	0.08
	-⅛	0.6	-0.2	-0.40	4.1	1.9	-1.00
	0	2.2	1.7	-0.71	6.3	4.5	-1.41
	+⅛				6.7	5.6	-1.92
	Market	-0.1	-0.2	-0.85	3.8	3.7	-0.31

The ex ante order transaction cost, $P^{ex\ ante}$, measures the extent to which the average price at which an order is filled betters the opposite-side quote prevailing at the time the order is submitted. For orders that are unfilled at the end of the day, a fill is imputed at the closing opposite-side quote for the day. Each cell reports the mean over all 52 days in the sample of the daily mean ex ante order transaction costs. The sample is described in the notes to Table 3.

[a] t-statistics (paired) for testing the equality of the daily buy and sell means.

TABLE 3

Numbers of Orders by Order Size and Limit Price Position

Order Size (Shares)	Limit Price Position[a]	Bid/Ask Spread at Time of Order Entry			
		$⅛		$¼	
		Sell	Buy	Sell	Buy
≤ 200	≤ −¼	1,114	1,197	570	668
	−⅛	803	889	328	418
	0	4,010	5,134	1,444	1,826
	+⅛			3,170	3,925
	Market[b]	42,577	49,659	24,588	28,507
201–500	≤ −¼	1,034	1,004	616	600
	−⅛	1,007	1,046	474	490
	0	4,680	5,585	2,281	2,574
	+1/8			3,718	4,557
	Market[b]	21,085	23,941	11,077	12,625
501–1,000	≤ −¼	1,271	1,209	702	716
	−⅛	1,478	1,392	707	715
	0	6,769	7,362	3,257	3,709
	+⅛			3,698	4,373
	Market[b]	13,331	14,461	6,319	6,784
> 1,000	≤ −¼	2,199	2,222	1,441	1,430
	−⅛	3,020	3,222	1,443	1,541
	0	11,723	12,924	5,751	6,024
	+⅛			4,160	4,900
	Market[b]	11,989	13,936	5,508	5,975

The sample consists of all market and limit orders in the System Order Database (SOD) component of the TORQ database (144 representative NYSE issues, November 1990 through January 1991) that were entered when the prevailing bid/ask spread was $¼ or less and were marked to expire at the end of the trading day. Furthermore, orders entered on November 9, 14, 27, 30, December 3, 31 of 1990, and January 10, 17, 24, 30, 31 of 1991 were excluded to ensure that the distribution of open-to-close index price changes in the analysis sample would be symmetric about zero.

[a]The limit price position is the extent to which the limit order price betters the existing quote.

[b]The "Market" order classification also includes marketable limit orders.

Table V

Frequency of Order Revisions and Trades, Given the State of the Book

For the 19 trading days in the period between October 29 and November 26, 1991, for the stocks included in the CAC 40 index at that time, Table V reports the empirical percentage frequency of the orders or trades, conditional on the previous state of the book. Each row is a probability vector (adding up to 100 percent) conditional on the previous state of the book. The latter is summarized by the magnitude of the bid-ask spread and the depth at the quotes. For each stock, the spread (depth) is defined to be large, if it is larger than its time-series median. To provide a benchmark, the last row gives the unconditional frequency of each order or trade.

	Appli-cations	Buy	New Bid Within	New Bid At	New Bid Below	Cancel Bid	Sell	New Ask Within	New Ask At	New Ask Above	Cancel Ask
Panel A: Large Spread											
Small Depth	2.1	13.1	11.65	6.5	8.6	4.6	18.1	10.9	5	7.25	4.1
Large Depth	2.2	12.8	14.5	5.1	7.15	4.75	24.8	13.5	4	6.6	4.4
Panel B: Small Spread											
Small Depth	2.15	20.7	4.6	5	7.5	4.5	35.3	4.3	4.35	7.3	4.5
Large Depth	2.2	21.25	5.45	4.5	6.3	5.1	34.85	4.8	4	6.8	4.8
Unconditional	2.2	18	9	5.3	7.4	4.7	30.2	8.3	4.3	7	4.8
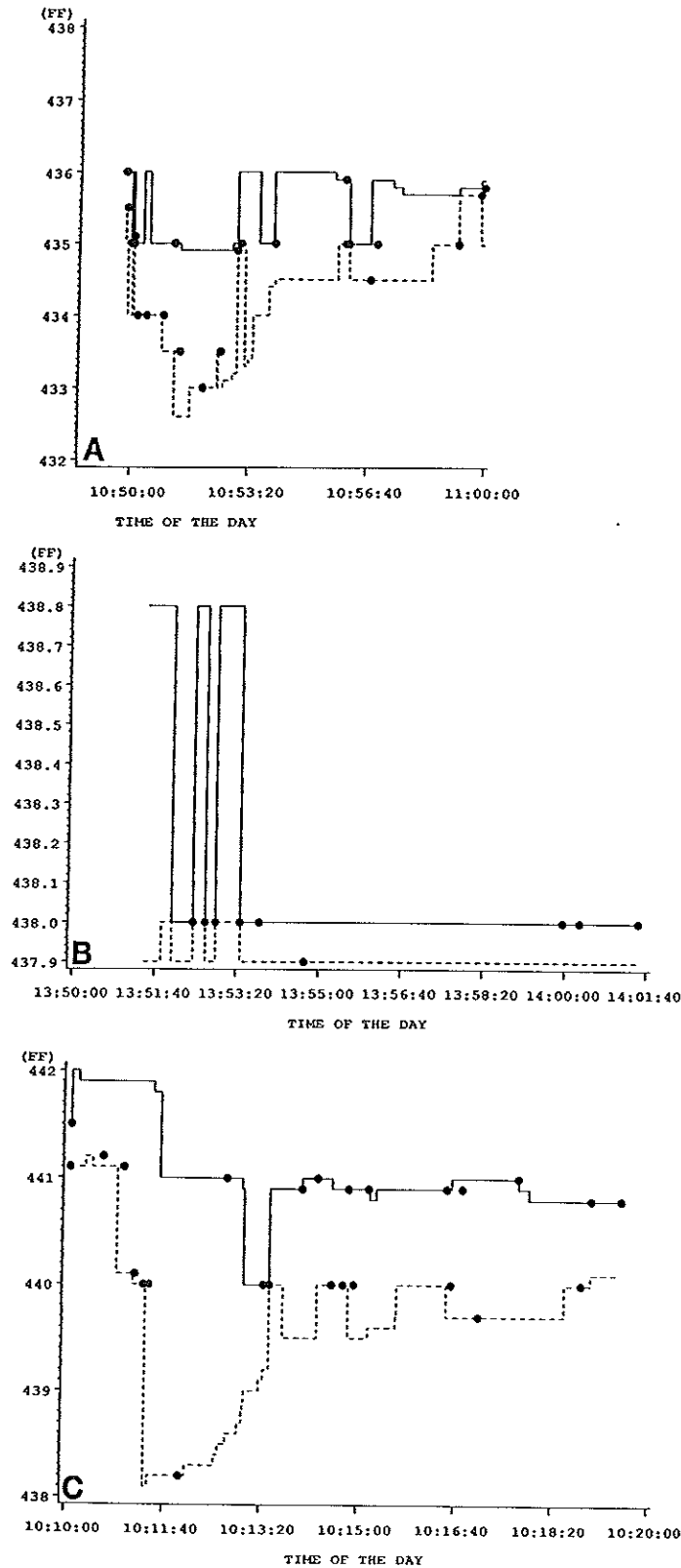
Figure 3. Transaction prices and bid and ask quotes for Elf-Aquitaine, November 9, 1991. (A) liquidity effects, undercutting, and mean reversion in the bid-ask spread (between 10:50 and 11:00 A.M.). (B) alternation of market buy and sell orders, and reversion in the spread (between 13:51 and 14:02 A.M.). (C) Information effects and undercutting (between 10:10 and 10:20 A.M.). Dots represent transaction prices, the full line represents the ask quote, and the dashed line represents the bid quote.

Figure A

26.75 ——————————— New Ask

26.5 ——— Original Ask   26.5 ——————— New Bid

26.375 ·············Sell Order   26.375 ····················Sell Order
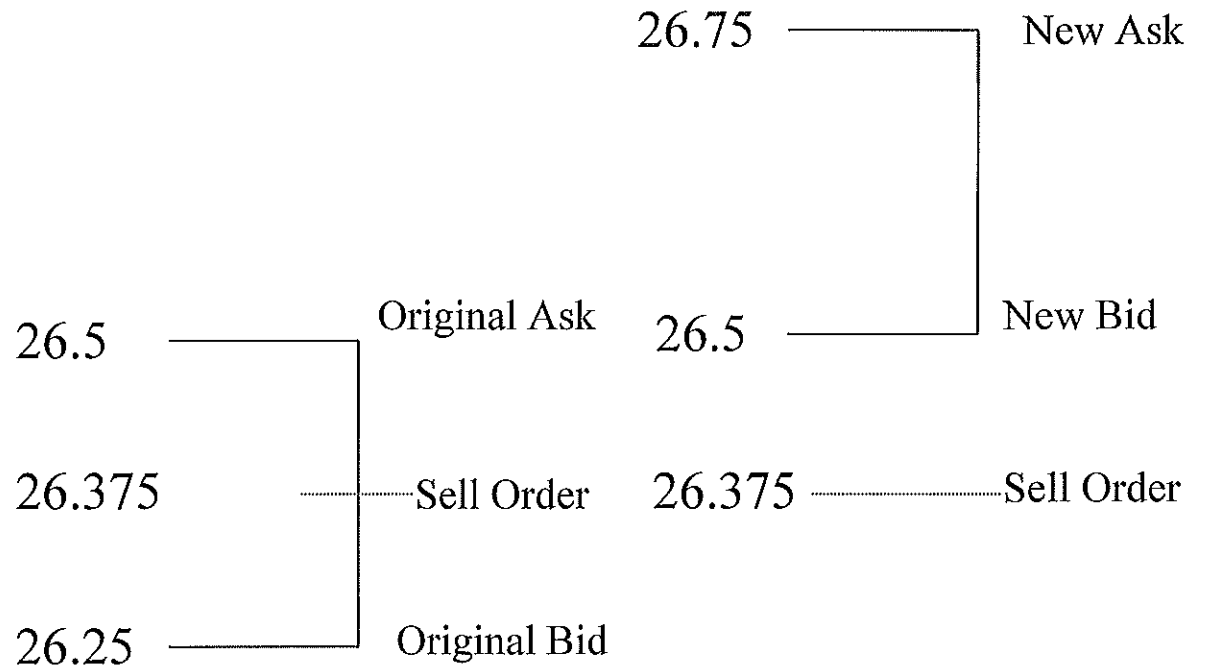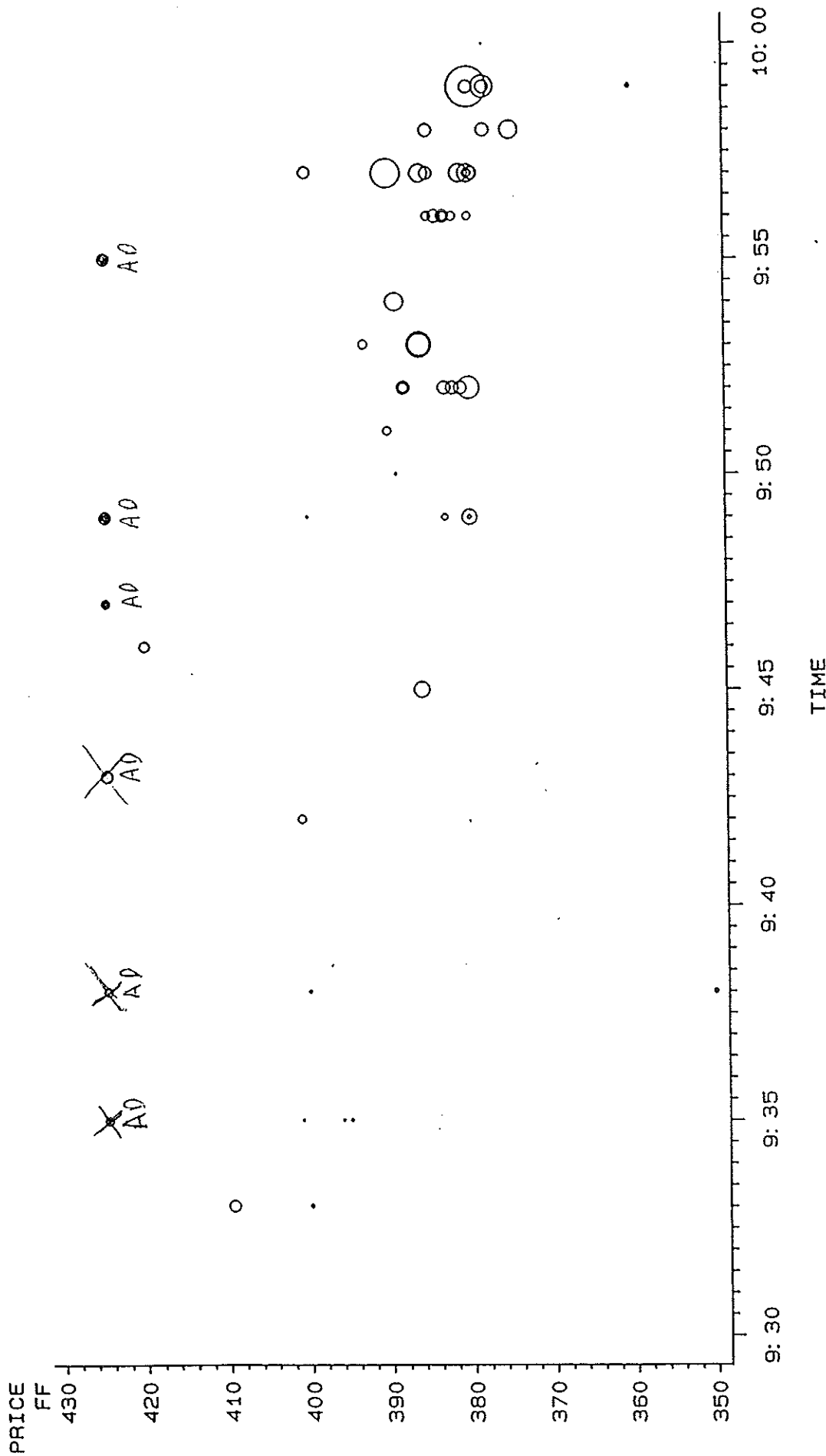
26.25 ——— Original Bid

FIGURE 1: PREOPENING ORDERS FOR SCHNEIDER ON OCTOBER 5, 1993
PANEL B: ORDERS PLACED BETWEEN 9:30 AND 10:00 a.m.

Pre-opening order quotes from 9:30:00 to 10:00:00

Orders Sorted By Volume

Ticker: 627 — Date: 5-10-1993   Var (10**4): 4.295 — # of orders: 85

FIGURE 1: PREOPENING ORDERS FOR SCHNEIDER ON OCTOBER 5, 1993
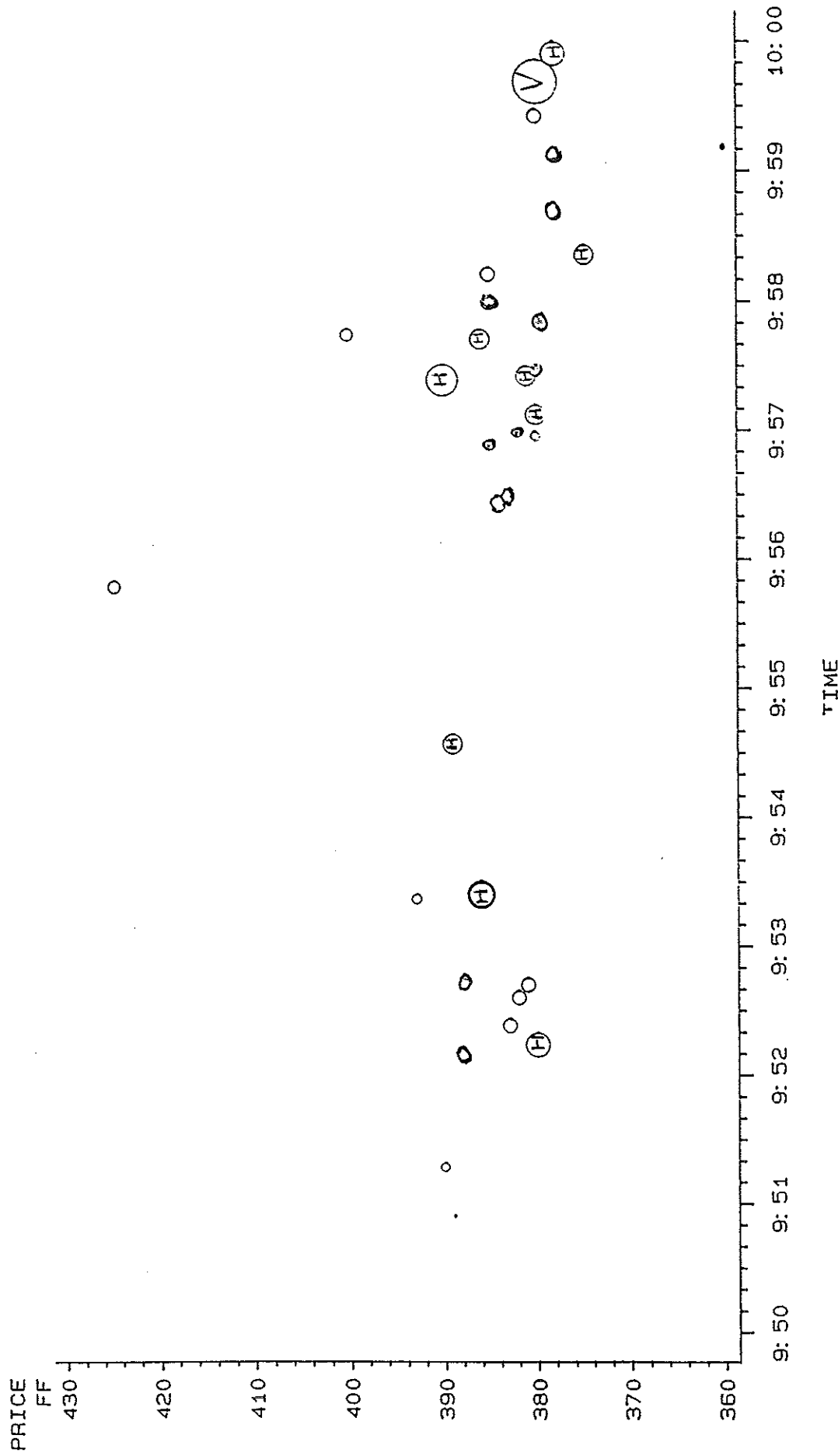## PANEL B: ORDERS PLACED BETWEEN 9:30 AND 10:00 a.m.

This figure depicts all orders placed for Schneider on October 5, 1993, during the preopening period. The horizontal axis is time. The vertical axis is the price of the order. Orders are represented by circles, the size of which increases with the size of the orders. By definition market orders do not have limit prices. We adopted the convention to depict all market buy and sell orders at the bottom of the figure.

In Panel B of Figure 1, we denote 6 orders, which we interpret as advertising orders, with AD. We cross 3 of these orders that were canceled before the opening. We fill in black the circles of the three other orders, that were executed at the opening.

FIGURE 1: PREOPENING ORDERS FOR SCHNEIDER ON OCTOBER 5, 1993
PANEL C: ORDERS PLACED BETWEEN 9:50 AND 10:00 a.m.

Pre—opening order quotes from 9:50:00 to 10:00:00

Orders Sorted By Volume

TIME

– Market Orc ᴸed–

Ticker: 627 – Date: 5-10-1993   Var (10**4): 4.295 – # of orders: 85

FIGURE 1: PREOPENING ORDERS FOR SCHNEIDER ON OCTOBER 5, 1993
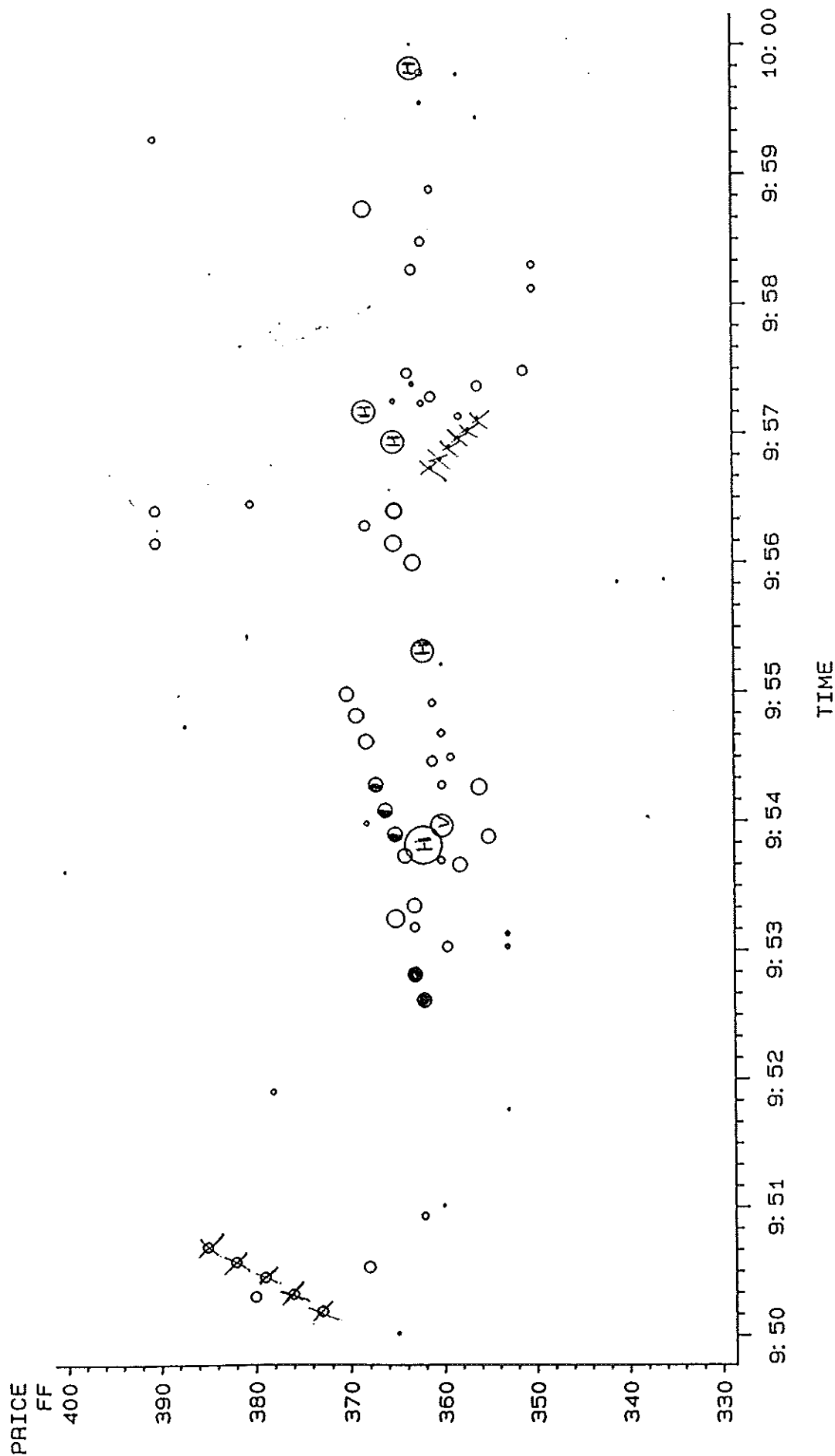## PANEL C: ORDERS PLACED BETWEEN 9:50 AND 10:00 a.m.

This figure depicts all orders placed for Schneider on October 5, 1993, during the preopening period. The horizontal axis is time. The vertical axis is the price of the order. Orders are represented by circles, the size of which increases with the size of the orders. By definition market orders do not have limit prices. We adopted the convention to depict all market buy and sell orders at the bottom of the figure.

In Panel C of Figure 1, for the 10 largest orders, we indicated whether the order was visible (V) or hidden (H).

FIGURE 2: PREOPENING ORDERS FOR SCHNEIDER ON OCTOBER 6, 1993
PANEL C: ORDERS PLACED BETWEEN 9:50 AND 10:00 a.m.

Pre—opening order quotes from 9:50:00 to 10:00:00

Orders Sorted By Volume

TIME

— Market Orders Excluded—

Ticker: 627 — Date: 6-10-1993

Var (10**4):1.951 — # of orders:190

FIGURE 2: PREOPENING ORDERS FOR SCHNEIDER ON OCTOBER 6, 1993
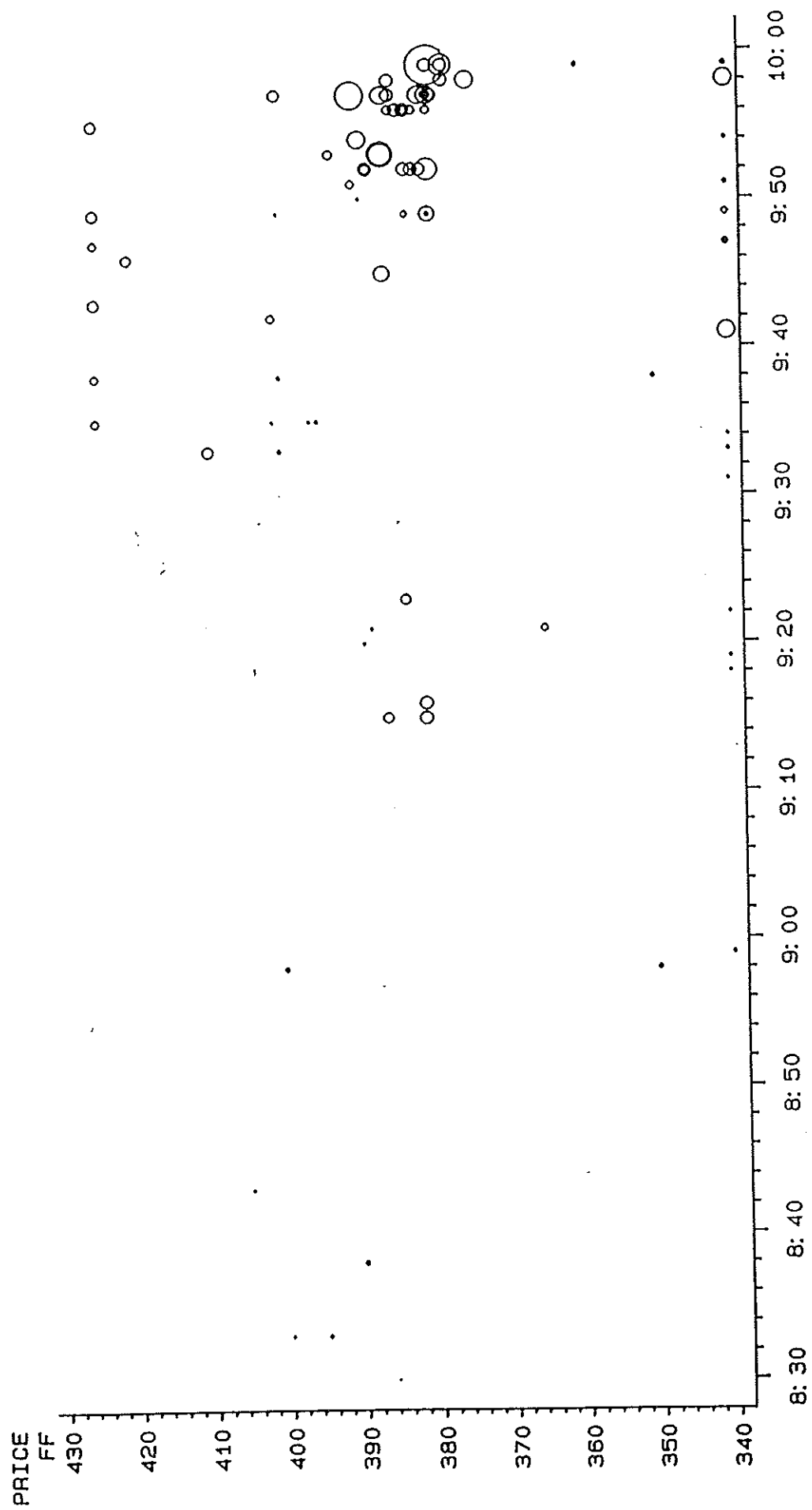## PANEL C: ORDERS PLACED BETWEEN 9:50 AND 10:00 a.m.

This figure depicts all orders placed for Schneider on October 6, 1993, during the preopening period. The horizontal axis is time. The vertical axis is the price of the order. Orders are represented by circles, the size of which increases with the size of the orders. By definition market orders do not have limit prices. We adopted the convention to depict all market buy and sell orders at the bottom of the figure.

In Panel C of Figure 2, for the 6 largest orders, we indicated whether the order was visible (V) or hidden (H). Also in Panel C of Figure 2, for 3 schedules we indicated if the order was executed at the opening (by filling the circle in black), if it was executed later in the day (by half filling the circle in black), or if it was canceled (by crossing it).

FIGURE 1: PREOPENING ORDERS FOR SCHNEIDER ON OCTOBER 5, 1993
PANEL A: ORDERS PLACED BETWEEN 8:30 AND 10:00 a.m.

Pre—opening order quotes from 8:30:00 to 10:00:00

Orders Sorted By Volume

TIME

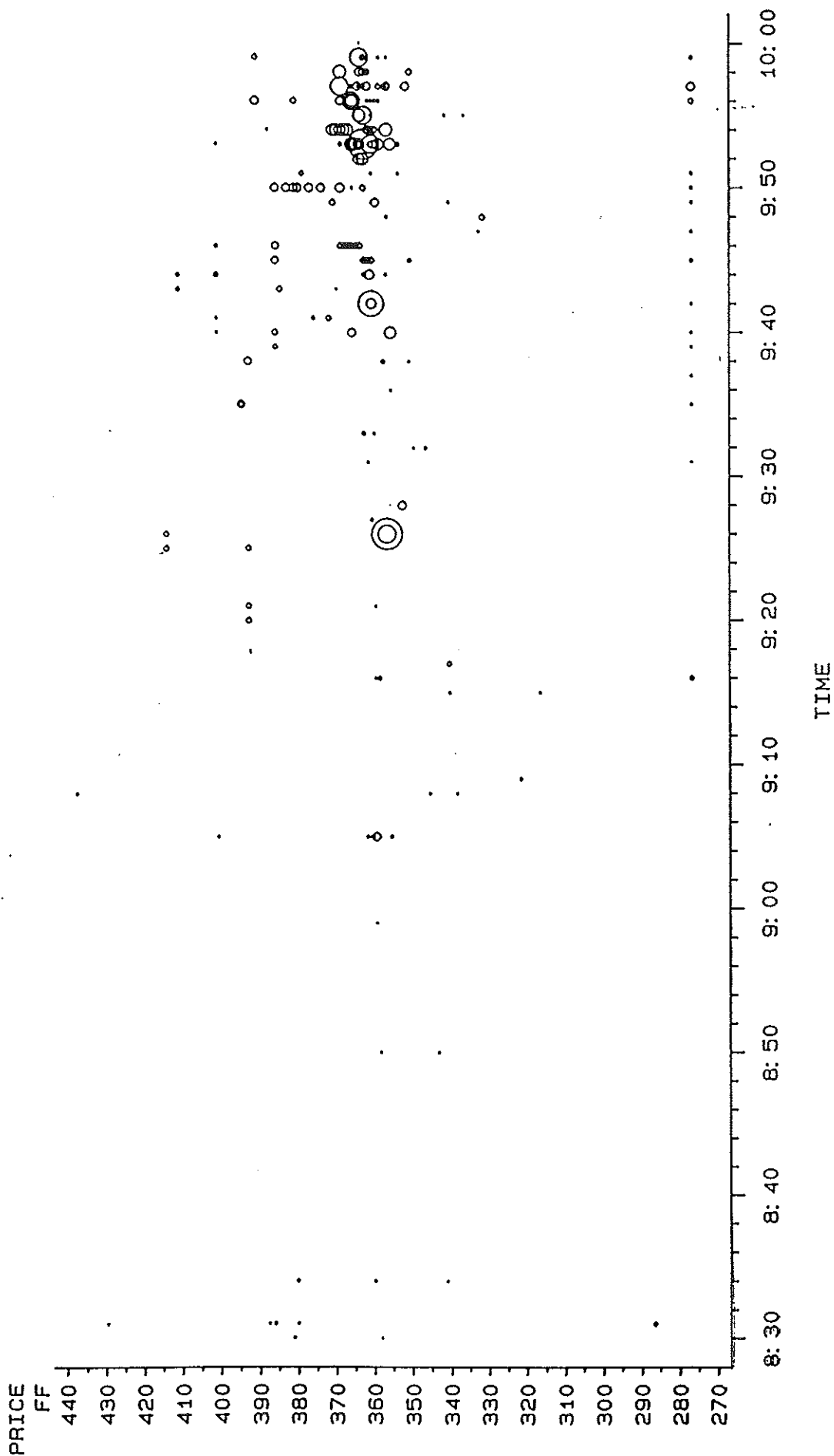— Market Orders Included—

Var (10**4): 4.295 — # of orders: 85

Ticker: 627 — Date: 5-10-1993

FIGURE 1: PREOPENING ORDERS FOR SCHNEIDER ON OCTOBER 5, 1993
PANEL A: ORDERS PLACED BETWEEN 8:30 AND 10:00 a.m.

This figure depicts all orders placed for Schneider on October 5, 1993, during the preopening period. The horizontal axis is time. The vertical axis is the price of the order. Orders are represented by circles, the size of which increases with the size of the orders. By definition market orders do not have limit prices. We adopted the convention to depict all market buy and sell orders at the bottom of the figure.

FIGURE 2: PREOPENING ORDERS FOR SCHNEIDER ON OCTOBER 6, 1993
PANEL A: ORDERS PLACED BETWEEN 8:30 AND 10:00 a.m.

Pre—opening order quotes from 8:30:00 to 10:00:00

Orders Sorted By Volume

TIME

— Market Orders Included—

Ticker: 627 — Date: 6-10-1993   Var (10**4):1.951 — # of orders:190

FIGURE 2: PREOPENING ORDERS FOR SCHNEIDER ON OCTOBER 6, 1993
PANEL A: ORDERS PLACED BETWEEN 8:30 AND 10:00 a.m.

This figure depicts all orders placed for Schneider on October 6, 1993, during the preopening period. The horizontal axis is time. The vertical axis is the price of the order. Orders are represented by circles, the size of which increases with the size of the orders. By definition market orders do not have limit prices. We adopted the convention to depict all market buy and sell orders at the bottom of the figure.
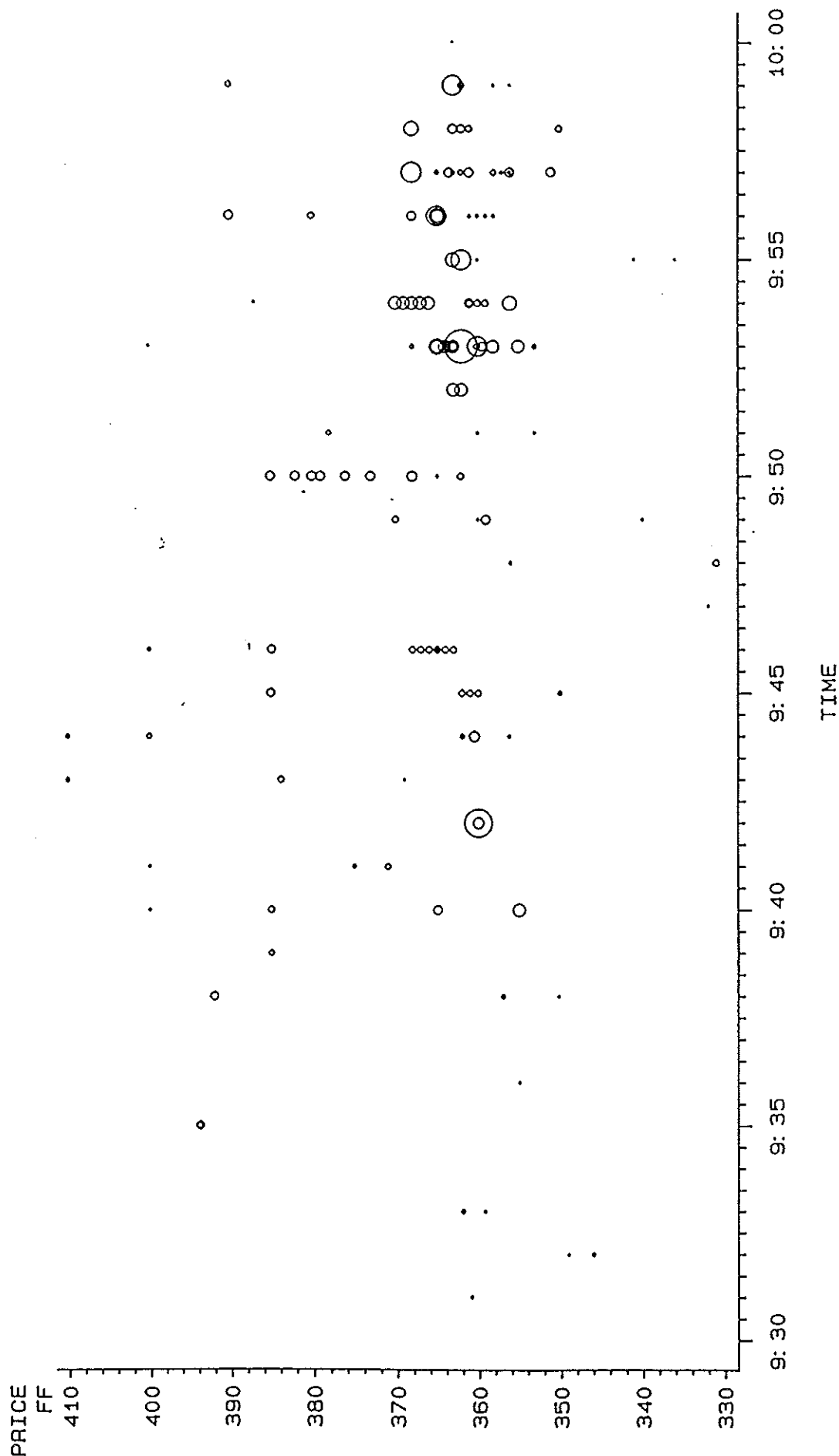
Table 10: Order Choices and Model Predictions

Buy Order Choices (N=1302)
Bid price - Ask Quote

	-5	-4	-3	-2	-1	Average
number of						
limit orders	80	109	177	403	533	
	2.5%	5.5%	3.4%	7.2%	10.7%	7.7%

Sell Order Choices (N=1750)
Ask Price - Bid Quote

Starting point	+5	+4	+3	+2	+1	
number of						Average
limit orders	119	93	223	521	794	
	0%	2.2%	1%	5.3%	3.3%	17.4%

Fraction of observed order choices that violate the monotonicity condition. Comparing the threshold associated with the choice with the threshold valuation for a market order.

Tables and Figures–5

Pre—opening order quotes from 9:30:00 to 10:00:00

Orders Sorted By Volume

TIME

— Market Orders Excluded—

Ticker: 627 — Date: 6-10-1993   Var (10**4):1.951 — # of orders: 190

FIGURE 2: PREOPENING ORDERS FOR SCHNEIDER ON OCTOBER 6, 1993
PANEL B: ORDERS PLACED BETWEEN 9:30 AND 10:00 a.m.

This figure depicts all orders placed for Schneider on October 6, 1993, during the preopening period. The horizontal axis is time. The vertical axis is the price of the order. Orders are represented by circles, the size of which increases with the size of the orders. By definition market orders do not have limit prices. We adopted the convention to depict all market buy and sell orders at the bottom of the figure.