2. Trading Mechanisms

This chapter surveys typical trading arrangements, and establishes an institutional context for the statistical and economic models to follow. This book focuses on continuous security markets. Whatever their original mechanisms, many and the most visible of these markets presently feature an electronic limit order book. The limit order market, then, is the starting point for the survey. This is probably the most important mechanism, but there are usually for any given security at least several alternative paths to accomplishing a trade. Most security markets are actually hybrids, involving dealers, clearings, one- and two-sided auctions, and bilateral bargaining, all of which are also discussed below. The survey emphasizes general features, and is not specific to particular securities or a particular country. The appendix to the book contains a supplementary overview of U.S. equity markets.

Whatever the mechanism, the event that we label a trade, execution or fill (of an order) actually only constitutes a preliminary agreement as to terms. This agreement sets in motion the clearing and settlement procedures that will ultimately result in the transfer of securities and funds. These processes are usually automatic and routine, and the traders seldom need to concern themselves with the details. It is important, though, that they require some sort of pre-existing relationship, possibly one that is indirect and via intermediaries, between the parties. Establishing a brokerage account or clearing arrangement is neither costless nor instantaneous, and may therefore create a short-run barrier to entry for a potential buyer or seller not previously "known" to the market.

Trading often involves a broker. A broker may simply provide a conduit to the market, but may also act as the customer's agent. This is a more substantial role, and may involve discretion about how to handle a customer's trading needs: when to trade, where to trade, what sort of orders to use, etc. The customer-broker agency relationship gives rise to the usual problems of monitoring, contracting and enforcement that pervade many principal-agent relationships. The broker's duty to the customer is sometimes broadly characterized as "best execution," but precise definition of what this means has proven elusive (Macey and O'Hara (1997)).

We now turn to the specific mechanisms.

2.1 Limit Order Markets

Most continuous security markets have at least one electronic limit order book. A limit order is an order that specifies a direction, quantity and acceptable price, e.g, "Buy 200 shares at $25.50 [per share]," or "Sell 300 shares at $30.00." In a limit order market, orders arrive randomly in time. The price limit of a newly arrived order is compared to those of orders already held in the system to ascertain if there is a match. For example, if the buy and sell orders just described were to enter the system (in any order), there would be no match: a price of $25.50 is not acceptable to the seller; a price of $30.00 is not acceptable to the buyer. A subsequent order to buy 100 shares at $32.00 could be matched, however, as there is an overlap in the acceptable prices. If there is a match, the trade occurs at the price set by the first order: an execution will take place (for 100 shares) at $30.

The set of unexecuted limit orders held by the system constitutes the book. As limit orders can be cancelled or modified at any time, the book is dynamic, and in active markets with automated order management it can change extremely rapidly. These markets are usually transparent, with the state of the book being widely visible to most actual and potential market participants. Short of actually trading, there is no better way to get a feel for their mechanics than by viewing the INET book (currently available at www.island.com) for an actively-traded stock (such as Microsoft, ticker symbol MSFT). The extraordinary level of transparency traders currently enjoy is a recent phenomenon. NYSE rules historically prohibited revelation of the book. In the 1990s this was relaxed to permit visibility of the book on the trading floor. Off-floor visibility was not available until January, 2002.[1]

A market might have multiple limit order books, each managed by a different broker or other entity. Limit order books might also be used in conjunction with other mechanisms. When all trading for a security occurs through a single book, the market is said to be organized as a consolidated limit order book (CLOB). A CLOB is used for actively traded stocks in most Asian and European markets.

A mechanism's priority rules govern the sequence in which orders are executed. Price priority is basic. A limit order to buy priced at 100, for example, will be executed before an order priced at 99. Time is usually the secondary priority. At a given price level, orders are executed first-in first-out. Although these priority rules may seem obvious and sensible, it should be noted that they usually only determine the relative standing of orders within a given book. There is rarely "system-wide" time priority across all books or other components of a hybrid market.

A trader may desire that an order be executed "at the market", i.e., at the best available price. If the order quantity is larger than the quantity available at the single best price on book, the order will "walk the book," achieving partial executions at progressively worse prices until the order is filled. This may lead to executions at prices far worse than the trader thought possible at the time of submission. For example, at 10:47:26 on January 29, 2001, the bid side of the book for IBM on the Island ECN contained (in its entirety) bids at $112.50, $110.00, $108.00, and $2.63. The last bid was presumably entered in error, but should it have been executed, a seller would have obtained $2.63 for a share of IBM at a time when its market price was in the vicinity of $113.[2]

A provision in the Euronext system illustrates how surprises of this sort can be avoided. On Euronext, a market order is not allowed to walk the book. It will only execute for (at most) the quantity posted at the best available price. Anything remaining from the original quantity is converted into a limit order at the execution price. For example, if a market order to buy 1,000 shares arrives when the best offer is 200 shares at 100€, 200 shares will be executed at 100€, and the remaining 800 shares will be added to the book as a buy limit order priced at 100€. If a trader in fact wants the order to walk the book, the order must be priced. Attaching a price to the order forces the trader to consider the worst acceptable price. INET requires that all orders be priced.

Markets often permit qualifications and/or variations on the basic limit order. The time-in-force (TIF) attribute of an order specifies how long the order is to be considered active. It is essentially a default cancellation time, although it does not preclude the sender from canceling before the TIF is reached. Although the precommitment associated with a TIF deprives the sender of some flexibility, it avoids the communication delays and uncertainties that sometimes arise with transmitted requests for cancellation. An immediate-or-cancel (IOC) order never goes onto the book. If it cannot be executed, it leaves no visible trace, and the sender is free to quickly try another order (or another venue). An all-or-nothing (AON) order is executed in its entirety or not at all. It avoids the possibility that a partial fill (execution) will, when reported to other traders, move the market price against the sender, leaving the remaining portion of the order to be executed at a less favorable price.

A trader seeking to buy or sell an amount that is large (relative to the quantities typically posted to the book) is unlikely to feel comfortable displaying the full extent of his interest. To make the situation more attractive, many markets allow hidden and/or reserve orders. Hidden orders are the simpler of the two. If an order designated as hidden cannot be executed, it is added to the book, but not made visible to other market participants. The hidden order is available for execution against incoming orders, the senders of which may be (happily) surprised by fills at prices that are better than or quantities that are larger than what they might have surmised based on what was visible. Hidden orders usually lose priority to visible orders, a rule that encourages display.

Reserve (“iceberg”) orders are like hidden orders, but their invisibility is only partial. Some display is required, and if the displayed quantity is executed, it is “refreshed” from the reserve quantity. The procedure mimics a human trader who might feed a large order to the market by splitting it up into smaller quantities (Esser and Mönch (2005)).

In a limit order market, buyers and sellers interact directly, using brokers mainly as conduits for their orders. The broker may also, however, provide credit, clearing services, information, and possibly analytics designed to implement strategies more sophisticated than those associated with the standard order types. The broker does not usually, however, act as a counterparty to the customer trade.

The data emanating from a limit order market are usually very accurate and detailed. The real-time feeds allow traders to continuously ascertain the status of the book, and to condition strategies on this information. For the economist, limit order markets offer a record of agents’ interactions at a level of detail that is rarely enjoyed in other settings. There are, nevertheless, some significant generic limitations. First, the sheer volume and diverse attributes of the data pose computational challenges, and make parsimonious modeling very difficult. More importantly, though, the unit of observation is typically the order, and it is rarely possible to map a particular order to others submitted or cancelled by the same trader. Market participants can’t construct these maps either (except for their own orders), so this does not preclude us from building models that might plausibly reflect agents common-knowledge beliefs. It does, however, constrain what we can discern about individual trading strategies.

2.2 Floor Markets

Consolidation of trading interest (actual and potential buyers and sellers) is important because it enhances the likelihood that counterparties will find each other. Before electronic markets allowed centralization of trading to be accomplished virtually, consolidation could only take place physically, on the floor of an exchange. In a floor market, the numerous and dispersed buyers and sellers are represented by a much smaller number of brokers who negotiate and strike bilateral deals face-to-face. These brokers are often called “members,” as the exchanges were historically organized as cooperatives.

The members act either as agents, representing the customer orders to others, or as principals, taking the other side of customer orders. The combination of these two functions, though, suffers from a conflict of interest. A broker who intends to act as a counterparty to his customer's order does not have an interest in vigorously representing the order to others on the floor (who might offer a better a price). For this reason, "dual trading" is either expressly forbidden or strongly regulated.

Despite behavior that may appear chaotic and noisy, floor trading is usually an orderly process. Hand signals quickly convey the key features of an order. Deceptive actions, such as bidding lower than another member's current bid (in an attempt to find a seller willing to trade at the inferior price), are forbidden. Transaction prices are quickly reported and publicly disseminated. Disputes and errors are resolved quickly.

In the 19th century, floor markets proliferated. In the 20th century, they consolidated. By the dawn of the 21st century, they had largely evaporated.[3] The largest markets that still rely primarily on trading floors are the U.S. commodity futures markets: the Chicago Board of Trade, the New York Mercantile Exchange, and Chicago Mercantile Exchange (the "Merc"). The last is perhaps the easiest for an outsider to comprehend, as its trading rules (available online) are particularly straightforward and clear. The New York Stock Exchange is sometimes described as a floor market. This is indeed its heritage, but the label has become less accurate as the Exchange has incorporated more electronic mechanisms.

From an empirical viewpoint, it is worth noting that the real-time data stream emanating from floor trading in futures markets is meager relative to what most electronic limit order markets provide. Futures "tick" data generally only convey price changes. In a sequence of trades, only those that establish new price levels are reported. Bids and offers can generally be obtained only by inquiry. Transaction volumes are not reported.

As measured by the capital generation and allocation that they facilitated, and by their historical survival and persistence, the floor markets achieved remarkable success. On the other hand, this success led to market power and political influence that sometimes worked against customers and regulators. In recent years, most floor-based trading has gone electronic. Like many paradigm shifts, the transition has been painful for the old guard. Most exchanges have nevertheless navigated the changes and survived, either by gradually automating or by building electronic markets de novo.

One event in particular seems to have starkly illuminated the costs of resisting the change. Through the mid-1990s, the market for futures based on German government debt (Bund futures) was dominated by a contract that was floor-traded on the London International Financial Futures Exchange (LIFFE). In 1997, the Deutsche Terminbörse (DTB, now Eurex) began to aggressively market an electronically traded contract. Over the course of the next year, trading shifted to the newcomer. The LIFFE eventually moved trading to an electronic platform, and shut down most floor trading by the end of 1999. It did not, however, recapture significant trading volume in the Bund contract (Maguire (1998), Codding (1999)).

Despite the rapid ascendancy of electronic systems, though, their limitations should not be overlooked. Electronic consolidation has not rendered face-to-face interactions irrelevant. Many of the same financial institutions that rely heavily on electronic access to markets have also gone to great lengths and expense to maintain the trading operations for their diverse markets together on large contiguous trading floors. This facilitates coordination when a deal involves multiple markets. The pricing and offering of a corporate bond, for example, might well involve the government bond, interest-rate swap, credit-swap, and/or the interest rate futures desks. Thus, while no longer necessary to realize in a single market economies of scale, personal proximity may promote across multiple markets economies of scope.

2.3 Dealers

2.3.1 Dealer Markets

A dealer is simply an intermediary who is willing to act as a counterparty for the trades of his customers. A dealer, or, more commonly, a network of geographically-dispersed electronically-linked dealers may be the dominant mechanism for trade. Some of the largest markets are dealer markets, including foreign exchange (FX), corporate bond and swap markets.

A trade in a dealer market, such as the FX market, typically starts with a customer calling a dealer. The dealer quotes bid and ask prices, whereupon the customer may buy at the dealer's ask, sell at the dealer's bid or do nothing. This script presumes that the dealer and customer have a pre-existing relationship. This relationship plays a more significant role (in addition to establishing the framework for clearing and settlement), because the customer's trading history and behavior may reveal the customer's unexpressed trading desires or information, and may therefore affect the terms of trade that the dealer offers.

The dealer-customer relationship involves reputations established and sustained by repeated interactions. The dealer's reputation is contingent on his willingness to always quote a "reasonable" bid and ask, even if the dealer would prefer not to trade in a particular direction. The customer's reputation is based on his frequent acceptance of the dealer's terms of trade. A customer who called the dealer repeatedly merely to check the price, never actually trading, would soon find the dealer unresponsive to his inquiries.

In a limit order market, a buyer who judges the book's best ask price unreasonable may place his own bid (buy limit order). In most dealer markets, this possibility does not exist. Dealers rarely act as an effective agent for customer limit orders. For example, prior to the Manning rules (in the mid-1990's), a Nasdaq dealer holding a customer limit order to buy was under no obligation to display the order, even when the customer's bid bettered those of all other dealers in the market (see Appendix Section A.3).

A large customer may have relationships with many dealers. This forms the basis for competition that mitigates the dealer's bargaining power. Small retail customers, however, often do not have such a pool, and therefore have little bargaining power.

Dealer markets are also usually characterized by low transparency. The dealers provide quotes only in response to customer inquiries, and these are not publicly visible. Publication of trade prices is unusual. Unlike consolidated floor markets, dealer markets are fragmented.

For customer orders, a dealer acts as a counterparty (trading against the order), while a broker acts as agent (representing the order on behalf of the customer). These two functions are not necessarily conflicting: both broker and dealer will profit by successful execution of the customer's order. Often, though, the broker and dealer are working at cross-purposes. An aggressive agent might survey more dealers and bargain harder to find the customer a good price, one that leaves the executing dealer with only a small profit. A lazy agent might simply take the first price quoted by the first dealer. As in floor markets, this conflict of interest is most aggravated when the broker and dealer are the same or affiliated entities.

In addition to dealer-customer interactions, interdealer trading is also important. The incoming orders that a particular dealer sees are rarely balanced (as to purchases and sales). There is usually an excess demand or supply, and accommodating these customer needs may leave the dealer with an undesired long or short position. In such cases, the dealer will attempt to sell or buy in the interdealer market. One dealer may contact another directly and non-anonymously, much as a customer might have initially contacted him (except that the quantity would typically be larger). Willingness to make a market and trade in these interactions is sustained by reputation and reciprocity. The dealer who is being contacted might soon need to reach out to balance his own position. Alternatively, a contact may be made indirectly and anonymously through a interdealer broker. Finally, interdealer trade in the FX market is typically conducted via a limit order book (such as EBS or Reuters). From the diversity of these examples, it is clear that the interdealer market is defined by its participants, not by the mechanism. Analyses of interdealer markets include Reiss and Werner (1998) and Viswanathan and Wang (2004).

Dealer markets are typically flexible. The fixed technology and infrastructure costs are low. The main barrier to entry is access to a set of customers. Dealing operations are easily scaled up or down. Certain terms of trade and security characteristics may be set to accommodate customer preferences. For example, the equity derivatives desk at a bank might sell a customer a call option for which the underlying, strike price, maturity, and size differ from any other option the desk has ever bought or sold.

2.3.2 Dealers in Hybrid Markets

Dealers can make markets work where they might otherwise fail. Recall that in a limit order market, customers trade directly with only a minimal role for the broker or any other intermediary. Liquidity, in the sense of the ability to trade immediately, is often described as customer-supplied because it derives from the unexecuted customer orders in the book. The absence of an intermediary helps to keep trading costs low. On the other hand, the customers' interests are driven by their immediate trading needs. They are not usually inclined to provide liquidity in an ongoing and continuous fashion. This may impair the functioning of the market because a trading venue's reputation for always accommodating trades contributes to its ability to attract order flow.

Limit order markets generally have difficulty with small stocks, securities for which trading interest is insufficient to sustain continuous trading. In many cases, continuous trading may not be necessary. That is, market participants may be satisfied with a call mechanism (described below) that provides for trading only at several specified times of the day. Continuous trading, though, offers more flexibility in hedging and rebalancing portfolios. A dealer may make continuous trading possible when the "natural" customer-supplied liquidity in the book would not suffice.

Ideally, dealers would arise endogenously, perhaps as customers who gain familiarity with the market in the course of managing their own trades, and then perceive opportunities in more actively supplying bids and offers. In actively-traded securities, this may well be occurring. In low-activity securities, though, the potential dealer's costs of continuously monitoring bids and offers may be too large to recover from the relatively infrequent trades. In these instances, continuous liquidity requires that a dealer be designated as such (by the market authority) and provided with additional incentives. Perhaps the best known designated dealer is the New York Stock Exchange specialist. The specialist has many roles and responsibilities, but an important one is maintaining a two-sided market when there is nothing on the limit order book and no one else on the floor bidding or offering.

Establishing the proper incentives for designated dealers, though, has proven to be difficult. The issues involve measuring the liquidity that the dealers provide, determining the beneficiaries of this liquidity, allocating the costs, and balancing the rights of dealers against the public users of limit orders (who are usually the dealers' direct competitors). The Euronext equity markets have adopted a relatively straightforward solution. Taking the position that a firm's stockholders are the most direct beneficiaries of continuous liquidity, a firm may contract with and directly compensate an agent who agrees to post continuous bids and offers. More typically, though, dealers are implicitly compensated in the form of trading profits, generated within a complex structure of privileges and obligations.

As a rough generalization, technology has weakened the competitive position of dealers (as it has, arguably, the competitive position of intermediaries in many non-security markets). Electronic order management systems, in particular, now enable customers to update and revise their limit orders rapidly enough to respond to market conditions. They can quickly supply liquidity when it is profitable to do so, and quickly withdraw their bids and offers when markets are volatile. The U.S. over-the-counter stock market (Nasdaq), for example, has historically been considered a dealer market. In recent years, though, trading activity has shifted onto limit order markets, and the dealer presence is considerably diminished.

Dealers also serve a useful function in facilitating large (block) trades. The block market (also called the upstairs market) is mainly institutional. When an institution contacts a dealer to fill a large order, the dealer can act as principal (taking the other side of the order and committing capital), try to locate a counterparty for the full amount, work the order over time, or some combination of these. The dealer's advantage here thus lies in access to capital, knowledge of potential counterparties, and expertise (or, nowadays, algorithmic systems) executing large orders over time. The relationship between the customer and dealer also expedites the trade. The customer implicitly warrants that his/her institution is "uninformed," specifically, not seeking to exploit a short-term informational advantage such as prior knowledge of an earnings announcement (Seppi (1990)).

2.4 Auctions and Other Clearing Mechanisms

When there are multiple buyers and multiple sellers concentrated in one venue at one time, trade need not be coordinated. Agents will contact each other sequentially, striking bilateral bargains. Economically inefficient outcomes, however, can easily arise.[4] Another practical consideration is that if the bargaining is conducted by brokers on behalf of customers, and the trade prices are publicly reported, many customers will see their trades executed at prices worse than the best price realized over the entire set of trades. This is unlikely to promote confidence in the brokers or the mechanism.

A single-price clearing avoids these problems. It is generally implemented with a single-price double-sided auction. Supply and demand curves are constructed by ranking bids and offers. Prices, quantities, and trader identities are usually determined by maximizing the feasible trading volume.

The double-sided auction is widely used in securities markets. For securities with low natural trading interest, most trade occurs using periodic auctions (also called "fixings"). The Euronext markets, for example, conduct auctions once or twice per day (depending on the level of interest). Double-sided auctions are usually used to open continuous trading sessions (Euronext, Tokyo Stock Exchange, NYSE, etc.). They are also frequently used at the close of continuous trading sessions. Closing prices are widely used as reference prices in valuing margin positions, valuing mutual fund shares, determining the payoffs to cash-settled derivatives, and (occasionally) determining terms of exchange in mergers. In these situations a small change in the reference price can cause substantial gains or losses in the derivative position. With so much at stake, it is not surprising that many cases of market manipulation involve attempts to "mark the close".[5]

Although auctions may appear simple, seemingly minor details of implementation can have profound effects. Paul Klemperer notes that, "What really matters in auction design are the same issues that any industry regulator would recognize as key concerns: discouraging collusive, entry-deterring and predatory behavior." Although the context of the statement is a discussion of single-side auctions, it is not a bad maxim for the double-sided security variety.

Experience suggests that a particularly important aspect of design is the deadline for order submission. As any casual observer of eBay activity can attest, most bidding action occurs very shortly before the final deadline (Roth and Ockenfels (2002)). Why bid early and give competitors a lengthy interval in which to contemplate their next moves? To discourage waiting until the last instant, the Euronext markets employ random stopping times. Within a brief window (on the order of seconds), order acceptance may be terminated at any point. This introduces uncertainty into the last-instant strategy, and so discourages its use.[6] The deadline may also be extended if the price at the scheduled clearing would constitute a large movement from a preceding price (such as the previous day's close).

To further minimize the noise in price determination, earlier deadlines may be imposed on large or "destabilizing" orders. (An order is destabilizing if it is in the same direction as the change in the likely clearing price, a buy order, for example, if the other orders cumulated to that time imply a clearing price above the previous close.) To prevent the strategy of entering orders on both sides of the market, and then canceling one at the last moment, cancellations of stabilizing orders are usually subject to the same early deadline as the submission of destabilizing orders.

Although most auctions in secondary (post initial offering) markets are double-sided, single-sided auctions are extensively used in primary (initial offering) markets. These include the U.S. Treasury debt markets, and most U.S. municipal bond offerings. Auctions are also used, though not as often, for initial issues of equity.

Single-sided auctions can sometimes arise as an ancillary mechanism in a market where most trading takes place by other means. In floor trading on the New York Stock Exchange, for example, one agent, the specialist, acts as agent for customer market orders (among his other responsibilities). In this role, the specialist may auction a market order by indicating quantity and direction (e.g., "2000 shares to buy") and letting other brokers compete to offer the best price.

The economic literature on auctions is extensive. Useful texts include (in order of ascending complexity) Klemperer (2004), Krishna (2002), and Milgrom (2004). Friedman and Rust (1993) is an excellent collection of articles focusing on double auctions.

2.5 Bargaining

Some security trading interactions closely resemble the usual customer/vendor situation in goods markets wherein a shopkeeper fixes a posted price and the passing customer can purchase (or not). Although the posted price is almost certain to be constrained by larger forces of competition (the customer's access to alternative suppliers or substitute goods), the interaction is essentially, in the microscopic view, a bargaining game. In securities trading, the retail customer and her dealer may be in a similar situation. A retail customer in the U.S. who wishes to buy or sell a municipal bond will contact his broker and solicit prices at which the broker (acting in a capacity as dealer) would buy or sell. The broker states the prices, and the customer can trade (or not). Faced with unfavorable terms an institutional trader might search the prices of other dealers with whom they have relationships, but individuals rarely have accounts with more than one broker. Recent work on the U.S. municipal securities markets highlights the role of bargaining power in a dealer market (Green, Hollifield and Schuerhoff (2005)).

In economic terms, this is an ultimatum game. In the standard full-information ultimatum game, one agent ("the allocator") proposes a division of the total payoff and the other agent ("the recipient") either accepts or rejects the proposal. If the recipient accepts, both players receive the proposed payoff; if the recipient rejects, both players receive zero. The main feature of this literature is the divergence between the predicted "rational" outcomes and those that arise in experiments (and in most individuals' experiences). The rational recipient accepts any proposal that gives him any nonzero payoff, and knowing this, the rational allocator keeps for herself almost all of the total payoff. In practice, recipients often reject proposals perceived as unfair, and this forces allocators to discipline their greed. The economic literature on these games in voluminous. Thaler (1988) and Camerer and Thaler (1995) are good introductions. Roth (1995) surveys experimental evidence.

When the total payoff is known to the allocator, but not the recipient, the latter cannot so readily assess the fairness of a proposal. This uncertainty favors the allocator, in this case, the dealer (see, for example, Kagel, Kim and Moser (1996)) . Perhaps the strongest signal about the total payoff in the dealer/customer interaction is the record of prices of recent trades. For this reason, U.S. regulators have sought to promote trade price publication through a variety of initiatives.[7]

Another standard bargaining situation arises in LiquidNet, a trading system for U.S. institutional investors. Institutions anonymously enter the quantities and directions (buy or sell) of desired trades. The Liquidnet system searches over all the entries. When it finds a match, it contacts the buyer and seller, and places them in a virtual meeting room, where they can (anonymously) bargain over price. The bargaining protocol essentially allows the recipient to reject the allocator's initial proposal and suggest another, and so on, indefinitely.

When the situation allows for repeated counter proposals, the Rubinstein (1982) theorem comes into play. Briefly, the theorem sets out some reasonable sufficient conditions (most importantly, time preference) under which the full-information game will immediately converge to the even-split outcome. The intuition is that both sides can clearly see the consequences of a strategy (which might at first seem reasonable) of making proposals that are far from an even split and marginally improving them ("I'll sell at $1,000"; "I bid one cent."; "I'm offering at $999.99."; "I bid two cents," etc.) This will simply dissipate value through delay. In a Liquidnet negotiation, both parties know bid and ask prices from other markets (although these will typically be for smaller quantities). Usually the midpoint of the best intermarket bid and offer is proposed and accepted.

2.6 Crossing Networks and Derivative Pricing

In a crossing, the buyer and seller are paired (usually anonymously) for an agreed-upon quantity. The trade is priced by reference to a price determined in and derived from some other market. Thus, while almost all of the devices considered prior to this can in principle serve as the sole market mechanism, a crossing network, in its reliance on a price determined elsewhere, is inherently a hybrid device.

In ITG's Posit system, for example, potential buyers and sellers enter demands (quantities to buy or sell). These are not made visible. At the time of the crossing, the system matches buyers and sellers (if possible). The execution price of the trade is the midpoint of best bid and offer in the listing market. Thirteen crossings are scheduled each day. The exact time of a cross is partially random, to discourage either side from entering a surreptitious bid or offer to obtain a more favorable price.

Instinet (an institutional brokerage) runs a cross where the match price is the average price of all trades on the day, weighted by volume. Buyers and sellers enter desired quantities and are paired off in the morning, prior to the start of regular trading. After the market closes in the afternoon, the value-weighted average price (VWAP) is computed, and the trades are executed.

In the both the Posit and Instinet VWAP crossings, quantities are matched prior to the determination of the price. A crossing can also use a price determined prior to the quantity matching. The Instinet closing cross allows institutions to submit, after the regular market close, orders that will be matched (if possible) and executed at the closing price. Instinet also conducts crossings in foreign exchange.

Crossings must be designed to discourage manipulation (if the price is determined after the quantity match) and predatory trading (if the price is determined prior to the quantity match). A strategy of the latter sort might involve submitting orders in response to news announcements made after the determination of the closing price, in the hopes of picking off unwary counterparties. In view of an after-hours announcement of a product recall, for example, the day's closing price is likely to be high relative to the following open. A sell order might trade against someone who hadn't heard the news and cancelled their buy order. To prevent this, Instinet cancels crosses when there are news announcements and monitors participants, expelling those whose strategies that appear to be "news driven".

Another form of derivative pricing is "price matching". This generally refers to a dealer's strategy of precommitting to execute orders at the best visible bid or offer (posted by others). The precommittment is made selectively, to brokers representing customers, typically retail customers, whose orders are likely to be profitable for the dealer.

The pricing in crossing markets is sometimes described as "derivative," a usage that sometimes leads to confusion. In finance, a derivative *security* has a value or payoff that is a function of some other security (the underlying). A derivative *mechanism* is a device for executing trades in a security based on a price determined for the same security in another market.

2.7 Concluding Remarks

The complexity of institutional arrangements and the rapid pace of their evolution force the modeler to exercise judgment in deciding which features are important to the task at hand. In practice, market microstructure analyses deal with the details at varying levels of abstraction.

Least demanding of fidelity to institutional details are the descriptive statistical analyses of high-frequency trade price behavior, which can be viewed as atheoretic forecasting models. At a higher level of complexity, we attempt to identify passive and active sides of trades (the bid and offer quotes, and the traders who hit or lift them). For these purposes, we might view, for example, the bids of dealers and the bids representing customer limit orders as equivalent. These models often have a fair degree of economic content, yet remain tractable to estimate.

In reality, though, the agent in a limit order market is intrinsically neither active nor passive, but instead makes a choice conditional on the state of the book. Embedding this choice in a dynamic structural model of price evolution has proven to be extremely difficult. For the most part, current models make and test predictions about the determinants of order choice.

Studies addressing regulatory issues require, obviously, detailed knowledge of the rules in question, but also an appreciation for how these rules are applied and interpreted in practice. Often a particular rule or feature is too difficult to model structurally, though, and we attempt to draw welfare conclusions based on comparisons of relatively crude descriptive statistics before and after the change. These conclusions must frequently be qualified due to confounding events and agents' responses to the rule changes. While it is relatively easy to assess direct trading costs (e.g., brokerage commissions), for example, it is virtually impossible to measure indirect costs (e.g. the cost of monitoring the status of a limit order) or the cost/benefits of degraded/enhanced risk sharing.