

Model-Based Trading

E4729 – Spring 2020

Lecture 2
Institutions and Mechanisms of Securities Trading

Agenda

Institutions and Mechanisms of Securities Trading

- Introduction to cash equity market structure
 - Market participants
 - Limit order markets
 - Floor markets
 - Dealer markets
 - Auctions
 - Other trading venue types
- Limit Order Books

Market Participants and Components

Market Participants

The participants in and components of U.S. equity markets may be summarized as follows:

- **Customers** - are *individuals* (retail) and *institutions* (pension funds, mutual funds and other managed investment vehicles, collectively known as the *buy side*). The distinction between *retail* and *institutional* customers is mainly one of size, and should not be construed as naïve versus sophisticated. Customers often actively compete with each other in the market-making process.
- **Brokers** - act as *agents* for the customer orders and/or provide market access and often provide non-trading *services* as well (such as advice and research).
- **Dealers** – commit capital to facilitate customer orders, and act as counterparty to (i.e. trade directly with) customers.
- Brokers and dealers are collectively known as the *sell side*.

Market Components

The components of U.S. equity markets may be summarized as follows:

- **Trading venues** - are simply *places* (real or virtual) where trades *occur*. The principal venues are:
 - *Exchanges* (also known as the *listed market*). Most important, the NYSE and NASDAQ, but also BATS, (recently IEX), and previously including American Stock Exchange, Chicago, Cincinnati and other regional exchanges (Philadelphia, Boston, Pacific etc.)
 - *Alternative trading systems* (ATSs) include *dark pools* (*broker owned and independent*), *crossing networks*, *electronic communication networks* (ECNs, e.g., Instinet,). Most ECNs are organized as *electronic limit order markets* (LOMs).

Market Components – continued

- **Regulators** - The primary regulator of trading in U.S. equity markets is the *Securities and Exchange Commission* (SEC). In 1933 Congress created the SEC and delegated to it primary authority to manage securities markets.

The SEC has in turn *delegated* authority to industry entities known as “Self-Regulatory Organizations” (SROs). The NYSE and National Association of Securities Dealers (NASD) are the principal SROs. Congressional mandates on securities markets generally take the form of broad directives that leave details up to the SEC, with some exceptions such as decimalization.

- **Market Data** - *Consolidate* and *disseminate* trade reports, quotes, so on.
- **Market (Inter)connectivity** - Connect the trading venues and permit one trading venue to send an order to another for purposes of *execution* and *access*. As markets have become more fragmented, these systems have become very important, arguably transcending the importance of any single venue. Also critical to the National Market System (NMS).

Trading Mechanisms

Trading Mechanisms

- Most markets (both displayed and non-displayed) feature an *electronic limit order book* (LOB).
- The limit order market is probably the most important mechanism of trading, and the starting point for most microstructure studies.
- But there are usually several alternative paths to accomplishing a trade for any given security.
- Most security markets are actually *hybrids*, involving *dealers*, clearing, one- and two-sided *auctions*, and bilateral *bargaining*, all of which are also discussed.

Centralized (“Floor” and Electronic) 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 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.

Agency vs. Principal

- These members act either as *agents*, representing customers order to others, or as *principals*, taking the other side of customer orders.
- The combination of these two functions, though, may suffer from a *conflict of interest*.
- A brokers who intends to act as counterparty to his or her customer's order does not have an interest in vigorously representing the order to others on the floor who might offer a better price.
- In practice, in most modern markets the the role of the broker acting as principal or agent is very clearly defined in transactions with clients, and is in fact restricted or regulated in many markets.

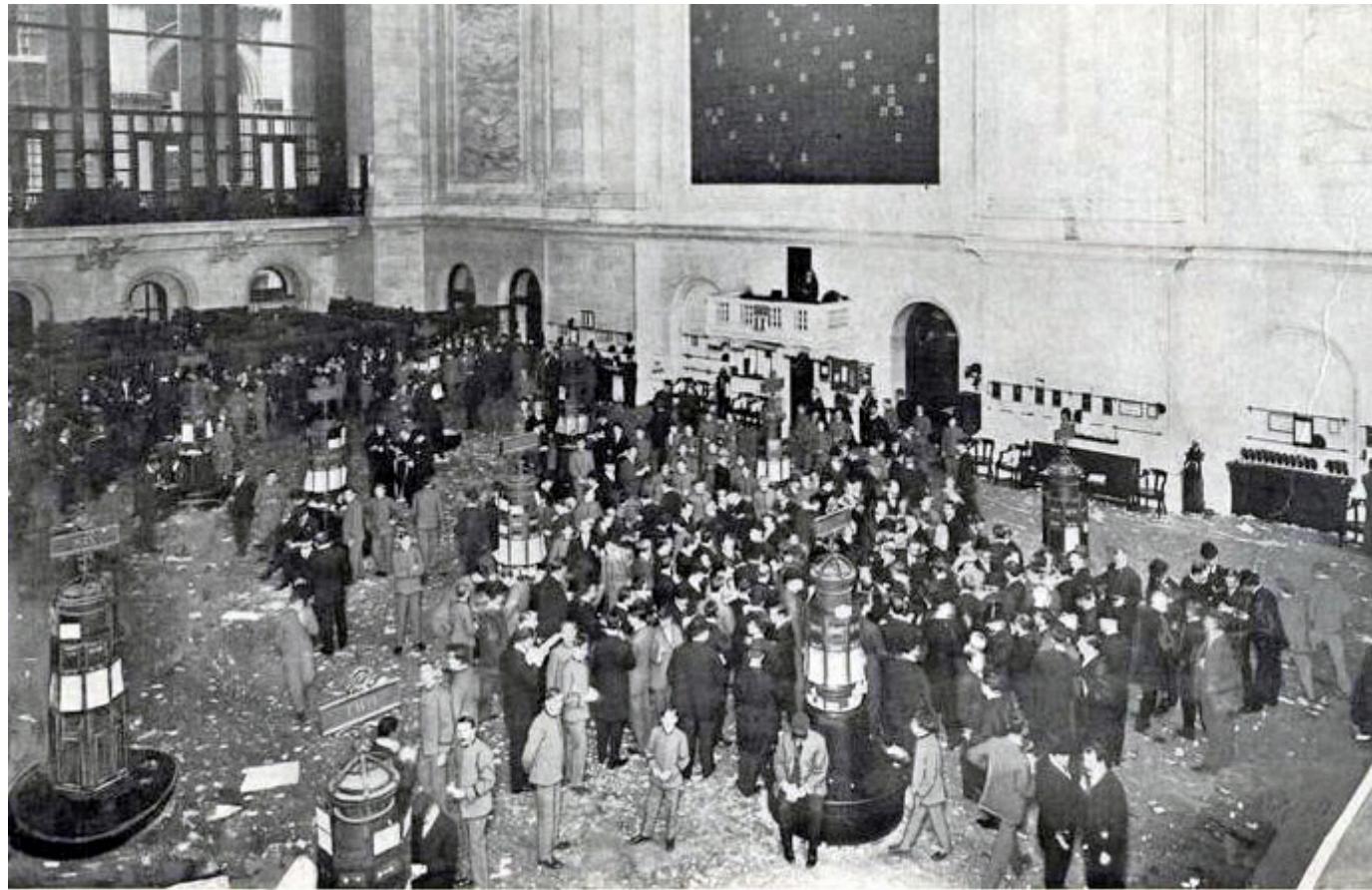
Trading Floor Evolution

- In the nineteenth century, floor markets proliferated.
- In the twentieth century, they consolidated.
- By the dawn of the twenty-first century, they had largely evaporated.
- The largest markets that still rely on trading floors are the U.S. *commodity futures* markets: the Chicago Board of trade (CBOT), the New York Mercantile Exchange (NYMEX), and Chicago Mercantile Exchange (CME/Merc).
- NYSE is sometimes described as a floor market, but the label has become less accurate as the Exchange has incorporated more electronic mechanisms.

Trading Floor Evolution

The New York Stock Exchange floor in 1908

Source: Wikipedia



Trading Floor Evolution

The New York Stock Exchange floor in 1963

Source: Wikipedia



Trading Floor Evolution

The New York Stock Exchange floor in 2009

Source: Wikipedia



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 \$28 [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: the price of 28 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 price for 100 shares at \$30.00.
- We will examine Limit Order Books in detail later.

Limit Order Markets

Brokers in LOMs

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

Limit Order Markets

Real-time Data in Limit Order Markets

- The *data* emanating from limit order market are usually very accurate and *detailed*.
- This real-time feed allows traders to *continuously* ascertain the *status of the book* and condition strategies on this information.
- This allows 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 modeling very difficult.
 - More importantly, though, the *unit* of observation is typically the *order*, and is *rarely* possible to map a particular order to others submitted or cancelled by the *same trader*, which can constrain what can be discerned about individual trading strategies.

Dealer Markets

- A dealer is an *intermediary* who is willing to act as *counterparty* for the trades of his customers.
- A dealer, or more commonly, a network of geographically dispersed electronic dealers, may be the dominant mechanism for trade.
- Some of the *largest* markets are dealer markets, including the *foreign exchange (FX)*, *corporate bond*, and *swap markets*.
- A trade in a dealer markets, such as FX market, typically starts with a customer calling a dealer.
- The dealer quotes bids and ask prices, whereupon the customer may
 - *buy at the dealers ask,*
 - *sell at the dealer's bid,*
 - *or do nothing.*
- This presumes that the dealer and customer have a preexisting relationship.

The Dealer-Customer Relationship

- This relationship plays a more significant role (in addition to establishing a framework for clearing and settlement) because the customer's *trading history* and *behavior* may reveal his or her unexpressed *trading desires* or *information* and may therefore *affect* the *terms of trade* the dealer offers.
- The dealer-customer relationship involves reputations established and sustained by repeated interaction.
- The *dealer's reputation* is contingent on his or her 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 or her 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 that the dealer unresponsive to his or her inquiries.

Dealers and Customer Limit Orders

- In a limit order market, a buyer who judges the book's best ask price unreasonable may place his or her own bid (buy limit order).
- In most *dealer markets*, this possibility does *not* exist. Dealers *rarely* act as effective agents for customer limit orders.
- For example, prior to the Manning rules (established in 1994), a NASDAQ dealer holding customer limit order to buy was under no obligation to display the order, even when the customer's bid was better than those of all dealers in the market.

Multiple Dealer Relationships

- 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 pool and therefore have little bargaining power.

Low Transparency

- Dealer markets are also often characterized by *low transparency*.
- The dealer provides quotes *only* in response to customer *inquiries*, and those are *not publicly visible*.
- Publication of trade prices is *unusual*. Unlike consolidates floor markets, dealer markets are *fragmented*.

Dealers vs Brokers

- For customer orders:
 - A dealer acts as a *counterparty* (trading with the customer and taking risk)
 - A broker acts as *agent* (representing the order on behalf of the customer).
- These two functions are not necessarily in *conflict*. Both broker and dealer will profit by successful execution of customer's order.
- Often, though, the broker and the dealer are working at cross purposes.
 - An aggressive agent might survey more dealers and bargain harder to find 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 the dealer are the same or affiliated entities.

Inter-Dealer Markets / Trading

- In addition to customer-dealer interactions, inter-dealer trading is also important.
- The incoming orders that a particular dealer sees are *rarely balanced*.
- There is usually an excess demand or supply, and accommodating these customer needs may leave the dealer with an *undesirable* long or short position (Inventory).
- In such cases, the dealer will attempt to sell or buy in inter-dealer market.

Inter-Dealer Markets / Trading

- One dealer may contact another directly and non-anonymously, much as a customer might have initially contacted him or her (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 or her own position (i.e. offset risk).
- Alternatively, a contact may be made indirectly and *anonymously* through an *inter-dealer market*.
- For example, inter-dealer trade in FX markets is typically conducted via a *limit order book* (such as EBS or Reuters).
- From the diversity of these examples, it is clear that the inter-dealer market is defined by its participants, not by the mechanism.

High Flexibility of Dealer Markets

Dealer markets are typically *flexible*:

- The fixed technology and infrastructure costs are low.
- The main barrier is *access* to a set of customers.
- Dealing operations are easily scaled up or down (and is generally a function of the dealer's risk tolerance / appetite)
- 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 deal has ever bought or sold.

Hybrid Markets and Dealers

- 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 order in the book.
- 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.
- Although continuous trading may not always be necessary, in the instances where it is desired a dealer may make continuous trading possible when the natural customer-supplied liquidity is the book would not suffice.

Designated Dealers / Specialists

- Ideally, a dealer would arise endogenously, perhaps as customers who gain familiarity with the market in the course of managing their own trades 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 continuous monitoring bids and offers may be too large to recover from relatively infrequent trades.
- In these instances, continuous liquidity provision requires that the dealer be *designated* as such by the market authority and provided with *additional incentives*. Perhaps the best known designated dealer is the NYSE 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.

Specialist Incentives

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

Dealers vs. Electronic Order Management Systems

- It can be argued that technology has weakened the competitive position of the dealer (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 markets.
- In recent years, though, trading activity has shifted on limit order markets, and the dealer presence is considerably diminished.

Block Trades

- Dealers also serve a useful presence in facilitating large (block) trades. The *block market* (also called the *upstairs market*) is mainly *institutional*.
- When an institution contacts the 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* from the full amount
 - *work the order* over time
 - or some *combination* of the 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 the dealer also expedites the trade. The customer implicitly warrants that his or her institution is “uninformed”, specially, not seeking to explicit a short-term information al advantage, such as prior knowledge of an earnings announcement.

Auctions and other Clearing Mechanisms

- When there are multiple buyers and multiple sellers concentrated in one venue at one time, trade need *not* be well *coordinated*.
- Agents will contact each other sequentially, striking bilateral bargains, and economically inefficient outcomes can easily arise.
- If bargaining is conducted by brokers on behalf of customers, and the trade prices are publicly reported, many customers will find that their trades are 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 trading mechanism.

Double-Sided Auctions

- A *double-sided auction* establishing a *single clearing price* can avoid this problem, and 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 level of interest).
- Double-sided auctions are usually used to *open* continuous trading sessions (Euronext, TSE, NYSE, etc.). They are also frequently used at the *close* of the continuous trading sessions.
- *Closing prices* are widely used as reference prices in valuing *margin positions*, valuing *mutual fund shares*, determining the *payoff* to cash-settled *derivatives*, and occasionally determining terms of exchange in mergers.
- In these situations, a small change in reference price can cause substantial gains or losses in derivative positions. With so much at stake, it is not surprising that many cases of market manipulation involve attempts to “mark the close”.

Auction Design and Implementation Issues

- Implementations issues for auction markets can be *challenging*. 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*.
- Experience suggests that a particularly important aspect of design is the *deadline for order submission*. Most bidding in actions occur very *shortly before* the final deadline in auctions (e.g. eBay).
- 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), auctions may be *terminated* at any point. This introduces uncertainty into the last instant strategy and so discourages its use.
- The deadline may also be *extended* if the price at the scheduled clearing would constitute a large movement from the proceeding price (such as the previous day's close).

Auction Design and Implementation Issues

- 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 the same direction as the change in likely clearing price, a buy order, for example, when the other orders cumulated to that time imply a clearing price above the previous close).
- To prevent the strategy of entering orders in both sides of the market and then canceling one at the last minute, cancellations of stabilizing orders are usually subject of 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.

Auctions in Primary and Secondary Markets

- 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 NYSE, for example, one agent (the specialist) acts as agent for customer market orders, among 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.

Alternative Trading Systems (ATSs)

- An ATS, also sometimes referred to as a crossing network, is a non-exchange trading venue that buyers and sellers may use as alternative sources of liquidity.
- In a *crossing*, the buyer and the seller are paired (usually anonymously) for an *agreed-on quantity*.
- The trade is priced by reference to price determined in and derived from *some other market*. Because of this dependency, this is sometimes referred to as “derivative pricing”.
- Thus, though most all of the devices considered prior to this can serve as the sole market mechanism, the crossing network, in its *reliance* on price determined elsewhere is inherently a *hybrid device*.

ITG's POSIT System: an early ATS and Dark Pool

- In this system for example, potential buyers and sellers enter demands (quantities to buy and sell).
- These are *not* made visible. This type of venue is also known as a *dark pool*.
- 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 *listed market*.
- When POSIT first started, thirteen crossings were scheduled every 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.
- Most dark pools operate as non-displayed continuous limit order books.

VWAP Cross – Pre-arranged Liquidity

- Instinet runs a cross where the match price is the *volume-weighted average price* (VWAP) – 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, VWAP is computed, and the trades are executed.
- In both the POSIT and Instinet crossing, quantities are matched prior to the determination of the price.
- A crossing can also use a price determined *prior* to the quantity matching.
- Instinet also has a “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 crossing in foreign exchange.

ATS Design Issues

- Crossing must be designed to *discourage manipulation* (if the price is determined after the quantity is matched) 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 hopes of picking off unwary counterparties.
- In view of an after-hour 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 appear to be news-driven.

Limit Order Books

The Order Book

- The set of *unexecuted limit orders* held by the system constitutes the “book”.
- Because limit orders can be *canceled* 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.
- The extraordinary level of transparency trades currently enjoy is a recent phenomenon. New York Stock Exchange (NYSE) rules historically prohibited visibility of the book, but in the 1990’s this was relaxed to permit visibility of the book on the trading floor. Off-floor visibility was not available until January 2002.
- 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 or central limit order book* (CLOB). A CLOB is used for actively traded stocks in most Asian and European markets.

Priority Rules

A mechanism's priority rules govern the *sequence* in which orders are executed:

- **Price priority** is basic. A limit order to buy price at 100 for example, will be executed before a buy 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 trading of orders within a given book. There is *rarely* a system-wide time priority across all books or other components of a hybrid market.
- This standard combination of Price and Time priority is collectively known as **Price-Time priority**.
- Some alternative trading venues use other priority mechanisms, such as **Price-Size priority**.

Market Orders vs Limit Orders

- A trader may desire that an order be executed “at the market”, that is, at the *best available price*. If the order quantity is *larger* than the quantity available at 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 execution 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 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, the seller would obtain \$2.63 for a share of IBM at the time when its markets price was in the vicinity of \$113.
- Euronext Market - 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, of a market order to buy 1000 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 the buy limit order priced at €100.
- If a trader in fact wants the order to walk the book, the order must be *priced* (as a market order). Attaching a price to the order forces the trader to consider the worst acceptable price. INET (Island/Instinet) requires that all order be priced.

Order Qualifications and Variations

Markets often permit qualifications and/or variations on the basic limit order:

- The **Time-in-Force** (TIF) attributes of an order specified *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 TIF is reached. Although the pre-commitment associated with TIF deprives the sender of some flexibility, it avoids the communication delays and uncertainties that sometime arise with the transmitted requests for cancellation. 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 *entirely* 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.
- **Hidden Orders:** 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.

Order Qualifications and Variations

- If an order designated as hidden can not 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 sender 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 often *lose priority* to the visible orders, a rule that encourages display.
- Reserve (“iceberg”) Orders: are like hidden orders, but they are only *partially invisible*. Some display is required, and if the displayed quantities 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.

Order Book Examples

Limit Order Characteristics: Summary

Order Characteristics

- ✓ Side (Buy or Sell)
- ✓ Type (Market or Limit)
- ✓ Time In Force (Assume Day)
- ✓ Quantity
- ✓ Price
- ✓ Modifiers
 - All or Nothing
 - Fill or Kill
 - Immediate or Cancel

Simple Limit Order Book: Stock XYZ

Bid Qty	Bid Px	Offer Px	Offer Qty
2000	100	100.01	2000
1000	99.99	100.02	1500
999	99.98	100.03	900
500	99.97	100.04	450

Characteristics

- Unexecuted Limit Orders
- Buys(Bids) and Sells(Asks/Offers)
- Price/Time Priority is common

Market Data

- Last Price = ?
- Last Qty = ?
- Best Bid Price = 100
- Best Bid Qty = 2000
- Best Offer Price = 100.01
- Best Offer Qty = 2000

New Limit Order Arrives

Bid Qty	Bid Px		Offer Px	Offer Qty
2000	100		100.01	2000
1000	99.99		100.02	1500
999	99.98		100.03	900
500	99.97		100.04	450

Buy 100 shares @ \$100

Is this “Marketable” ?

New Limit Order Arrives

Bid Qty	Bid Px		Offer Px	Offer Qty
2100	100		100.01	2000
1000	99.99		100.02	1500
999	99.98		100.03	900
500	99.97		100.04	450

Buy 100 shares @ \$100

Market Data

- Last Price = ?
- Last Qty = ?
- Best Bid Price = 100
- Best Bid Qty = 2100
- Best Offer Price = 100.01
- Best Offer Qty = 2000

New “Marketable” Limit Order Arrives

Bid Qty	Bid Px	Offer Px	Offer Qty
2100	100	100.01	2000
1000	99.99	100.02	1500
999	99.98	100.03	900
500	99.97	100.04	450

Buy 100 shares @ 100.01

New “Marketable” Limit Order Arrives

Bid Qty	Bid Px	Offer Px	Offer Qty
2100	100	100.01	1900
1000	99.99	100.02	1500
999	99.98	100.03	900
500	99.97	100.04	450

Buy 100 shares @ 100.01

Market Data

- Last Price = 100.01
- Last Qty = 100
- Best Bid Price = 100
- Best Bid Qty = 2100
- Best Offer Price = 100.01
- Best Offer Qty = 1900

New Market Order Arrives

Bid Qty	Bid Px		Offer Px	Offer Qty
2100	100		100.01	1900
1000	99.99		100.02	1500
999	99.98		100.03	900
500	99.97		100.04	450

Buy 1000 shares @ Mkt

New Market Order Arrives

Bid Qty	Bid Px	Offer Px	Offer Qty
2100	100	100.01	900
1000	99.99	100.02	1500
999	99.98	100.03	900
500	99.97	100.04	450

Buy 1000 shares @ Mkt

Market Data

- Last Price = 100.01
- Last Qty = 1000
- Best Bid Price = 100
- Best Bid Qty = 2100
- Best Offer Price = 100.01
- Best Offer Qty = 900

A Big Market Order Arrives

Bid Qty	Bid Px		Offer Px	Offer Qty
2100	100		100.01	900
1000	99.99		100.02	1500
999	99.98		100.03	900
500	99.97		100.04	450

Sell 3000 shares @ Mkt

A Big Market Order Arrives

Bid Qty	Bid Px	Offer Px	Offer Qty
100	99.99	100.01	900
999	99.98	100.02	1500
500	99.97	100.03	900
		100.04	450

Sell 3000 shares @ Mkt

First trade: 2100 @ 100

Second trade: 900 @ 99.99

Market Data

- Last Price = 99.99
- Last Qty = 900
- Best Bid Price = 99.99
- Best Bid Qty = 100
- Best Offer Price = 100.01
- Best Offer Qty = 900

Reserve / “Iceberg” Orders

Bid Qty	Bid Px	Offer Px	Offer Qty
2000(5000)	100	100.01	900
1000	99.99	100.02	1500
999	99.98	100.03	900
500	99.97	100.04	450

Sell 3000 shares @ Mkt

Reserve / “Iceberg” Orders

Bid Qty	Bid Px	Offer Px	Offer Qty
2000(2000)	100	100.01	900
1000	99.99	100.02	1500
999	99.98	100.03	900
500	99.97	100.04	450

Sell 3000 shares @ Mkt

One trade: 3000 @ 100

**Rules and Features Vary*

Market Data

- Last Price = 100
- Last Qty = 3000
- Best Bid Price = 100
- Best Bid Qty = 2000*
- Best Offer Price = 100.01
- Best Offer Qty = 900

Dark Pools (Non-displayed)

Bid Qty	Bid Px		Offer Px	Offer Qty
2000	100		100.01	2000
1000	99.99		100.02	1500
999	99.98		100.03	900
500	99.97		100.04	450

- Book is not visible
- Trades happen when orders cross (like displayed book)
- Price set relative to reference price (usually NBBO or equivalent)
- Why do we trade there??

Reg NMS

Mkt	Bid Qty	Bid Px		Offer Px	Offer Qty	Mkt
NASD	2000	100		100.01	2000	BATS
BATS	1000	99.99		100.02	1500	NASD
IEX	999	99.98		100.03	900	ARCA
ARCA	500	99.97		100.04	450	IEX

Reg NMS

- National Best Bid/Offer (NBBO)
- Order Protection / Trade Through
- Access Rule
- Sub-Penny (if P > \$1, tick = 0.01)
- Market data rule

NBBO and Order Protection

- Must trade at best displayed price regardless of venue
- Example: an order to buy 500 XYZ @ 100.03 must be executed first at the National Best Offer (BATS)
- Fragmentation / Increased competition
- Complex routing rules
- Latency arbitrage

Other Order Type Variations

- Hidden Orders
- Peg orders
- Market on Open / Close (MOC / LOC)
- Limit on Open / Close (LOO / MOO)

- How do we use these order types? (routers, algos)
- Implications for Algos
 - Flexibility, open quantity
 - Signalling
 - Ability to cancel

Next Lecture

- Market Data Management
- Intro to Trading Strategies