Basics of Market Microstructure

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January 2, 2026

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1 Markets and Limit Orders

1.1 Introduction to Trading Mechanics

We now move on from the basics of financial statements and risk-return relationships to the mechanics of trading on exchanges. Transaction costs eat into investment returns, so it is important to understand how to measure these costs and manage orders to minimize them.

1.2 What is an Order?

An order is a set of instructions sent to an exchange (usually via a broker) to trade a financial security. Every order must specify:

1. **Security:** The asset to trade, usually identified by a Ticker Symbol (e.g., AMZN for Amazon, F for Ford).
2. **Side:** Whether to Buy or Sell.
3. **Quantity:** The number of shares or units to trade.

Orders may also include additional instructions, such as price limits, expiration terms, or exchange routing.

1.3 Market Orders

A **Market Order** is the simplest type of order, containing only the three required instructions (Security, Side, Quantity).

- **Definition:** An order to execute the trade immediately at the best currently available price.
- **Pros:** Execution is almost certain.
- **Cons:** Price is uncertain. You accept whatever the market offers, which might be unfavorable in volatile conditions.

Example: A market order to buy 100 shares of Twitter guarantees you get the shares, but the price is determined by the market at the moment of execution.

1.4 Limit Orders

A **Limit Order** allows the trader to specify the price at which they are willing to trade. This specified price is called the **Limit Price**.

- **Buy Limit Order:** Sets a **maximum** purchase price. The trade executes only at the limit price or lower.

- **Sell Limit Order:** Sets a **minimum** selling price. The trade executes only at the limit price or higher.

Example: If you place a limit order to buy Twitter at $19, you ensure you never pay more than $19. If the market price is $19.50, the order will not execute.

1.5 Summary: Market vs. Limit Orders

- **Market Orders:** Execution is certain; Price is uncertain.
- **Limit Orders:** Price is controlled (certain not to be worse than limit); Execution is uncertain.

Most modern exchanges are **Electronic Limit Order Markets**, where limit and market orders interact to facilitate trading.

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2 Limit Order Book

2.1 Introduction

In this section, we examine how limit orders enter the order book and await execution. We will define key concepts such as the best bid and ask prices, the bid-ask spread, and market depth. Furthermore, we will observe how market orders and marketable limit orders interact with the order book to generate trades.

2.2 Definitions

- **Best Ask Price:** The lowest price at which someone is willing to sell shares.
- **Best Bid Price:** The highest price at which someone is willing to buy shares.
- **Bid-Ask Spread:** The difference between the best ask price and the best bid price.
- **Depth:** The number of shares available for trading at a specific price level.

2.3 Order Book Dynamics: An Example

Consider the limit order book for a hypothetical stock, XYZ Incorporated. Initially, the order book is empty.

2.3.1 Step 1: Arrival of Passive Orders

A trader sends an order (**S1**) to sell 150 shares of XYZ with a limit price of $40.

- This order sits on the sell side.
- **Current Best Ask:** $40.

A few seconds later, a buy order (**B1**) for 225 shares at $39.95 enters the market.

- S1 is not willing to sell below $40, and B1 is not willing to pay more than $39.95. They do not execute.
- **Current Best Bid:** $39.95.
- **Bid-Ask Spread:** $40 - 39.95 = \$0.05$.

These orders (S1 and B1) are referred to as **Standing** or **Passive Limit Orders**. They provide liquidity and face execution uncertainty (no guarantee they will be filled).

2.3.2 Step 2: Improving the Bid

Another buy order (**B2**) arrives for 500 shares at $39.97.

- B2 does not match S1 ($40), but it offers a higher price than B1.
- **New Best Bid:** $39.97.
- **New Spread:** $40 - 39.97 = \$0.03$.

Current Depth:

- Depth at Best Ask ($40): 150 shares.
- Depth at Best Bid ($39.97): 500 shares.

2.3.3 Step 3: Market Order Execution

A market order (**S2**) to sell 300 shares arrives.

- Market orders trade at the current best available prices.
- S2 interacts with the best bid (B2 at $39.97).
- **Execution:** 300 shares trade at $39.97.
- **Result:** S2 is filled completely. B2 has 200 shares remaining $(500 - 300)$.
- The Best Bid price remains $39.97, but depth has decreased to 200.

2.3.4 Step 4: Marketable Limit Order

A sell order (**S3**) arrives for 250 shares with a limit price of $39.95.

- S3 is willing to sell at $39.95 or higher. The best bid is $39.97 (higher than limit), so it executes immediately.
- **Trade 1:** 200 shares execute against the remainder of B2 at $39.97. (B2 is now filled).
- S3 still needs to sell 50 shares. The next best bid is B1 at $39.95.
- **Trade 2:** 50 shares execute against B1 at $39.95.

- **Result:** S3 is filled. B1 has 175 shares remaining $(225 - 50)$.

Marketable Limit Orders (Active Orders): S3 is an example of a marketable limit order. Like a market order, execution was immediate (no uncertainty). However, price was uncertain (executed at multiple prices: \$39.97 and \$39.95), though never worse than the limit price.

2.3.5 Final State

- **Best Ask:** \$40 (S1, 150 shares).
- **Best Bid:** \$39.95 (Remainder of B1, 175 shares).
- **Spread:** \$0.05.

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3 More Limit Order Book

3.1 Introduction

In this section, we explore what happens when a marketable limit order cannot be fully executed due to price restrictions. We also examine how large market orders execute against the book, moving prices and creating **price impact**.

3.2 Expanding the Order Book Example

Let's advance the state of the order book from the previous section.

- **Existing Orders:** S1 (Sell 150 @ \$40.00) and B1 (Buy 175 @ \$39.95).

We add the following new orders:

- **Sell Side:**
  - S4: 500 shares @ \$40.02
  - S5: 1,000 shares @ \$40.05
  - S6: 1,500 shares @ \$40.10
- **Buy Side:**
  - B3: 600 shares @ \$39.99
  - B4: 900 shares @ \$39.96

Current State:

- **Best Ask:** \$40.00 (S1)
- **Best Bid:** \$39.99 (B3)

- **Bid-Ask Spread:** $0.01

Note: In reality, market depth at a specific price is often the aggregate of multiple orders. For simplicity, we assume one order per price level here.

3.3 Partial Execution of Marketable Limit Orders

A new buy order (**B5**) arrives for **400 shares** with a limit price of **$40.00**.

Execution Logic:

1. B5 is willing to pay up to $40.00.
2. The best ask is S1 (150 shares @ $40.00).
3. **Trade:** 150 shares execute at $40.00. S1 is filled.
4. **Remaining B5:** 250 shares $(400 - 150)$ still need to be bought.
5. The next best ask is S4 at $40.02. Since B5's limit is $40.00, it cannot execute against S4.

Result: The remaining 250 shares of B5 enter the book as a standing limit order at $40.00.

- **New Best Bid:** $40.00 (B5, 250 shares).
- **New Best Ask:** $40.02 (S4, 500 shares).
- **New Spread:** $0.02.

3.4 Large Market Orders and Price Impact

A large market order (**B6**) arrives to buy **2,000 shares**. (*Note: Market orders have no price restrictions and execute immediately against available liquidity*).

Execution Logic: B6 sweeps through the sell side of the book until filled:

1. **Trade 1:** 500 shares @ $40.02 (Clears S4).
2. **Trade 2:** 1,000 shares @ $40.05 (Clears S5).
3. **Trade 3:** 500 shares @ $40.10 (Partially fills S6).

Total filled: $500 + 1,000 + 500 = 2,000$ shares.

Observations:

- **Price Uncertainty:** Although execution was guaranteed, the price varied. The average price paid is higher than the initial best ask.
- **Price Impact:** The aggressive buying pressure moved the best ask price from $40.02 to $40.10. This change ($0.08) represents the price impact of the order.

Post-Trade State:

- **Best Ask:** \$40.10 (Remaining 1,000 shares of S6).
- **Best Bid:** \$40.00 (B5).
- **Spread:** \$0.10.

3.5 Restoring Liquidity

A new sell order (**S7**) enters at **\$40.05** for 500 shares.

- This improves the best ask from \$40.10 to \$40.05.
- **New Spread:** \$0.05.

3.6 Summary: Liquidity Provision vs. Consumption

- **Liquidity Providers:** Orders that sit in the book awaiting execution (e.g., S1, B5 remainder). They offer options for others to trade against.
- **Liquidity Consumers:** Orders that execute immediately (e.g., B6). They remove liquidity from the book.

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4 Limit Price Placement

4.1 Introduction

Limit price placement refers to where the limit price of an order lies relative to the current best quotes (Best Bid and Best Ask). This concept is central to defining **Order Aggressiveness**.

Baseline for Examples:

- **Best Ask:** \$40.00 (150 shares).
- **Best Bid:** \$39.95 (235 shares).

4.2 Hierarchy of Order Aggressiveness

Aggressiveness depends on how far the limit price is from the best quotes.

4.2.1 1. Market Orders (Most Aggressive)

Market orders have no price restrictions.

- A market sell order can be viewed as a limit order with a price of \$0.
- A market buy order can be viewed as a limit order with a price of infinity (∞).

4.2.2 2. Marketable Limit Orders (Instant Full Execution)

These are limit orders that execute immediately and completely because their prices cross the spread significantly.

- **Buy Order:** Limit Price $\geq$ Best Ask.
- **Sell Order:** Limit Price $\leq$ Best Bid.

Aggressiveness Logic: The further the price crosses the spread, the more aggressive it is. A sell order at \$39.25 is more aggressive than one at \$39.50. A buy order at \$40.40 is more aggressive than one at \$40.20.

4.2.3 3. Marketable Limit Orders (Partial Execution)

Orders that cross the spread but have a size larger than the available depth at the best price.

- **Example:** Sell 500 shares at \$39.95.
- **Result:** Since the best bid depth is only 235 shares, 235 shares execute immediately. The remaining 265 shares sit on the book (or execute against lower bids if available).

4.2.4 4. Quote Improving Orders

Orders that do not execute immediately but improve the Best Bid or Best Ask. They narrow the Bid-Ask Spread.

- **Example Sell:** Limit price \$39.99 (Improves Best Ask from \$40.00).
- **Example Buy:** Limit price \$39.97 (Improves Best Bid from \$39.95).

4.2.5 5. Quote Matching Orders

Orders that simply add depth to the existing best quotes without changing the price.

- **Example:** Buy 50 shares at \$39.95.
- **Result:** Best Bid remains \$39.95, but depth increases from 235 to 285 shares.

4.2.6 6. Behind the Quote Orders (Least Aggressive)

Orders placed at prices worse than the current best quotes.

- **Example:** Buy 500 shares at \$39.90.
- **Result:** The order sits in the book behind the best bid, awaiting execution.

4.3 Liquidity Demanding vs. Liquidity Supplying

- **Liquidity Demanding (Consuming):** Orders that result in at least partial execution upon submission (Categories 1, 2, and 3). They trade against existing orders.

- **Liquidity Supplying (Providing):** Orders that sit on the order book awaiting execution (Categories 4, 5, and 6). They provide the liquidity that others demand.

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5 Stop-Loss Orders

5.1 Introduction

In this section, we discuss stop-loss orders and their purpose. These orders, also known as **stop orders** or **stop market orders**, are primarily used to prevent losses on existing positions.

5.2 How Stop-Loss Orders Work

Example: Suppose you bought 100 shares of XYZ Incorporated at $40 per share. You want to limit your potential loss to 10%. You place a stop-loss order to sell 100 shares with a **stop price** (or **trigger price**) of $36.

- **Visibility:** Stop-loss orders are held separately and do not appear in the public limit order book.
- **Triggering:** As long as trades occur above $36, the order remains dormant. If a trade executes at $36 or below, the stop order is triggered.
- **Execution:** Once triggered, it becomes a **regular market order** to sell. It executes against available orders in the book.
- **Price Uncertainty:** The actual execution price may be at, below, or even above $36, depending on market volatility in the split second between triggering and execution.

5.3 Trigger Price vs. Limit Price

It is crucial to distinguish between a limit order and a stop order with the same price.

- **Limit Sell Order ($36):** Guarantees you will not sell for less than $36. It is an instruction to sell at $36 or higher.
- **Stop-Loss Sell Order ($36):** Activates only when the market price drops to $36. It does not guarantee a minimum price; it guarantees entry into the market to exit the position.

5.4 Selecting the Trigger Price

The trigger price should be chosen relative to the stock's volatility.

- **Scenario:** You set a trigger 10% below purchase price, but the stock has a daily volatility of 15%.

- **Risk:** The order is likely to be triggered by normal daily fluctuations rather than a sustained downturn.
- **Best Practice:** Stop-loss orders should protect against sustained adverse price movements, not regular noise.

5.5 Stop-Limit Orders

To mitigate price uncertainty, traders can use **Stop-Limit Orders**.

- **Mechanism:** When the trigger price is hit, the order becomes a **limit order** rather than a market order.
- **Parameters:** You must specify both a **Trigger Price** and a **Limit Price**.
- **Trade-off:**
  - **Stop-Loss Market Order:** Guaranteed execution, uncertain price.
  - **Stop-Limit Order:** Controlled price, uncertain execution. In a fast-crashing market, the price may drop below your limit before you get filled, leaving you with the position.

5.6 Stop-Loss for Short Selling

While the examples above assume a long position (buy then sell), stop-loss orders are also used for short positions (sell then buy). If you sell shares expecting a drop, you can place a stop-loss buy order to protect against price increases.