Securities Trading:
Principles and Procedures

Chapter 8: Transaction costs

What does it *cost* to trade?

The long-term investor vs. the short-term trader

- We often differentiate *investment* and *trading* activities
  - The investment process is long-term.
    - It involves valuation and selection of securities, and portfolios.
  - The trading process is short-term.
    - It involves analysis of market conditions and execution strategies.
- Most long-term investors trade only to implement investment decisions.
  - They experience trading as a cost.
  - How should trading costs be measured?

Trading and investment: why make the distinction?

- Separation (different people, different roles)
  - Portfolio manager vs. trading desk vs. broker
- Delegation
  - Many investment managers (like mutual funds and pension funds) are working on behalf of beneficiaries (fund shareholders, retirees).
  - Trading costs are passed on to the beneficiaries.
  - The investment managers are legally responsible for monitoring trading costs.

The implementation shortfall approach (Andre Perold, 1988).

- Perold originally defined the *implementation shortfall* as:
  - *Return/profits on a paper portfolio – Return/profits on actual portfolio*
  - "Paper" here means hypothetical, notional, imaginary.
- The paper and actual portfolios have the same composition (hold the same securities) at all times.
  - Their investment returns are the same.
- The total returns differ because
  - All trades in the paper portfolio are assumed to be made at *benchmark prices* represent the "value" of a security at a given time.
  - Trades in the actual portfolio are made in real markets, at real market prices.

Perold's original implementation shortfall includes

- Explicit costs
  - Commissions, net of any rebates
    - ETRADE charges about $10 per retail trade; Scottrade charges about $7; Interactive Brokers charges about $1.
  - Transactions taxes
- Implicit costs
  - Costs of interacting with the market (e.g., bid-ask or price impact costs), relative to the benchmark prices.
  - Opportunity costs (the penalty associated with not completing intended trades)
  - Delay (failure to accomplish the trade immediately)

The implementation shortfall as practiced today.

- Usually computed at the level of the order (not the overall portfolio).
- For an executed order, usually defined as:
  - $Implementation\ Shortfall =$
    $\begin{cases} Trade\ Price - Benchmark\ Price, \text{for a buy order} \\ Benchmark\ Price - Trade\ price, \text{for a sell order} \end{cases}$
- This definition does not include commissions, delay, opportunity costs, and so forth, which are sometimes tabulated separately

A special case: the *effective cost*

- The implementation shortfall for a single trade relative to a benchmark equal to the midpoint of NBBO (also called the bid-ask midpoint, BAM) at the time the order was generated.
- p is the trade price; m is the prevailing NBBO midpoint.
- $Effective\ Cost = \begin{cases} p - m, \text{ for a marketable buy order} \\ m - p, \text{ for a marketable sell order} \end{cases}$
- For a buy order: "How much did I overpay, relative to the NBBO midpoint?"
- For a sell order: "How much less did I receive, …"?

Implementation shortfall for orders executed over time.

- Large investors and portfolio managers (PMs) often generate large orders that are worked over time.
  - "Buy 200,000 shares of HZO over the next three days."
- The large original order is called a *parent order*.
  - It is usually broken down into many smaller *child orders.*
  - The child orders are executed over time.
- The execution price used in the implementation shortfall calculation is the share-weighted average price.

Example: A purchase of 10,000 shares.

- At the time the order is sent, the NBB is 20.02; the NBO is 20.05. The order executes in three steps.
  - 3,000 shares @ 20.05
  - 2,000 shares @ 20.06
  - 5,000 shares @ 20.08
- The NBBO midpoint is 20.035.
- The share-weighted average execution price is
  - $\frac{3{,}000}{10{,}000} \times 20.05 + \frac{2{,}000}{10{,}000} \times 20.06 + \frac{5{,}000}{10{,}000} \times 20.08 = 20.067$
- The implementation shortfall relative to the BAM is $20.067 - 20.035 = \$0.032$ per share.

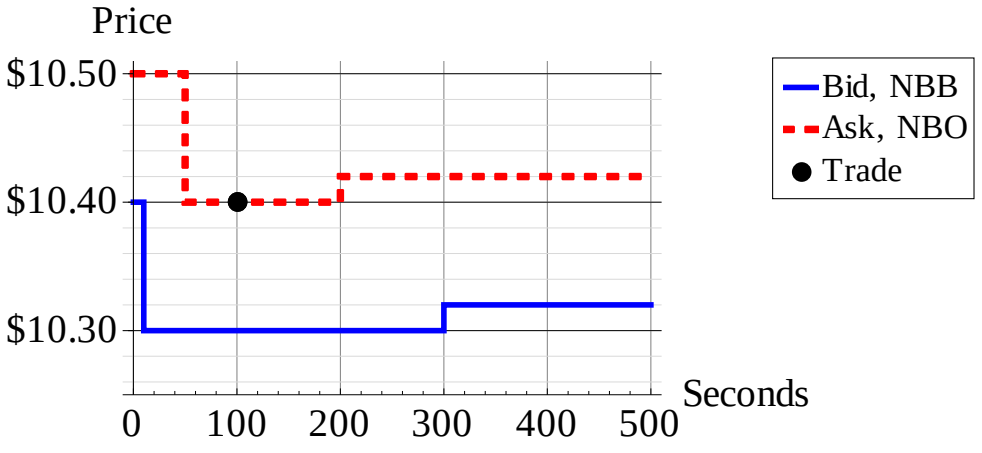
Alternative choices for the benchmark price

- The NBBO midpoint (BAM) at the time the trading or order submission decision was made is probably the most common benchmark.
  - It is a *pre-trade* benchmark (determined before the execution)
- An NBBO midpoint after the trade (a post-trade benchmark).
- Time-weighted average price (TWAP, "Tee Wap")
  - Computed over the day or duration of the order.
- Value-weighted average price (VWAP, "Vee Wap")
  - Average price per share for all trades (not just our own)
  - Computed over the day or duration of the order.
  - This is probably the second most common choice.

Cost calculations for individual marketable orders

- Marketable: the order is executed immediately.
- In addition to the effective cost, we often examine
  - Price improvement
  - Realized cost
  - Price impact

Example: A buy order executes at the NBO



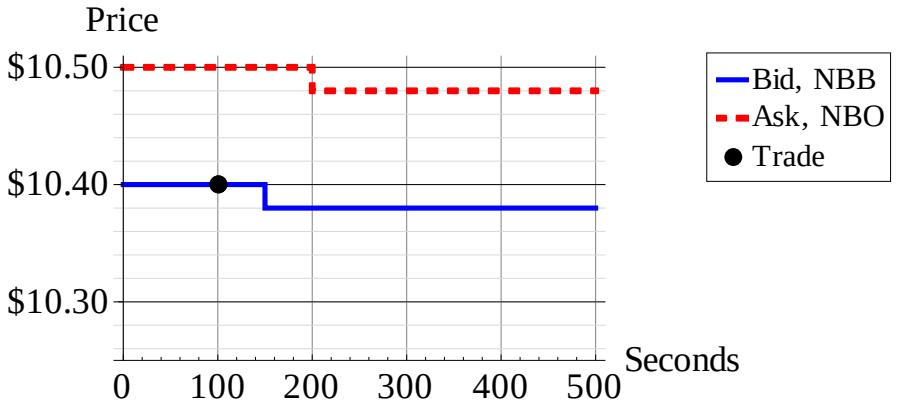
The realized cost for an executed order

- The implementation shortfall using as a benchmark the NBBO midpoint 5 minutes after.
- $Realized\ Cost = \begin{cases} p - m_5, \text{ for a marketable buy order} \\ m_5 - p, \text{ for a marketable sell order} \end{cases}$
  - Where m_5 is the NBBO midpoint 5 minutes post trade.
- Sometimes interpreted as the profit of the "dealer" who took the other side of the order.
  - For a customer sell order, the dealer reasons, "I bought from the customer at p; the stock is now worth m_5: my profit is $m_5 - p$."
  - For this to be a realized trading profit, the dealer must be able to resell at the NBBO midpoint.

Price impact

- $Price\ impact = Effective\ cost - Realized\ cost$
  - For a buy, $price\ impact = (p - m) - (p - m_5) = m_5 - m$
  - For a sell, $price\ impact = m - m_5$
- Price impact measures the movement of the quote midpoint (over five minutes) in the direction of the trade.
  - "If we bought, how much did the midpoint rise?"
  - "If we sold, how much did the midpoint fall?"

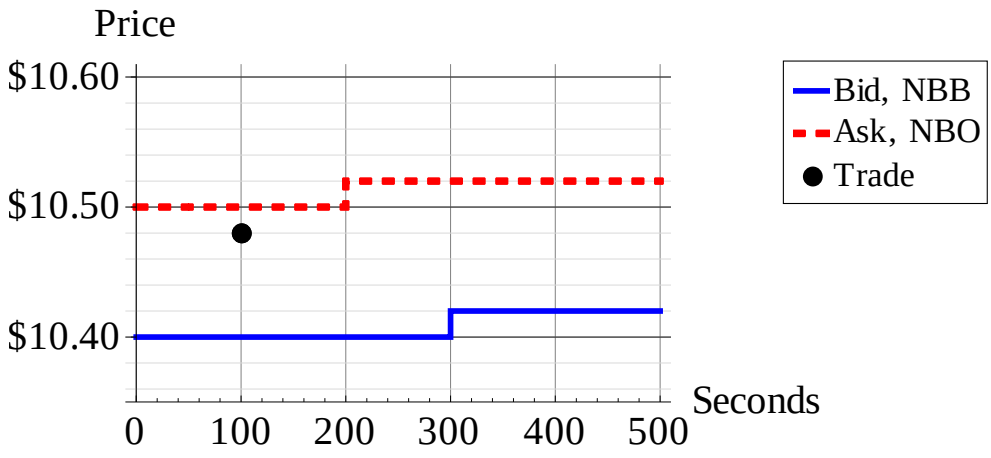
A sell order executes at the NBB



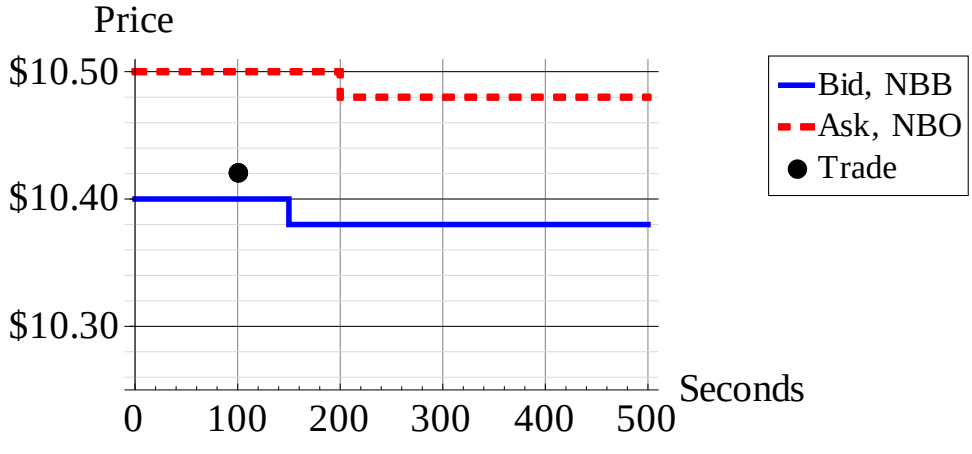
Price improvement

- We expect a marketable order to be executed at the quote (NBB or NBO)
- If we trade at a better price, the difference is price improvement.
- $Price\ improvement =$
  $\begin{cases} NBO - p, & \text{for a marketable buy order} \\ p - NBB, & \text{for a marketable sell order} \end{cases}$

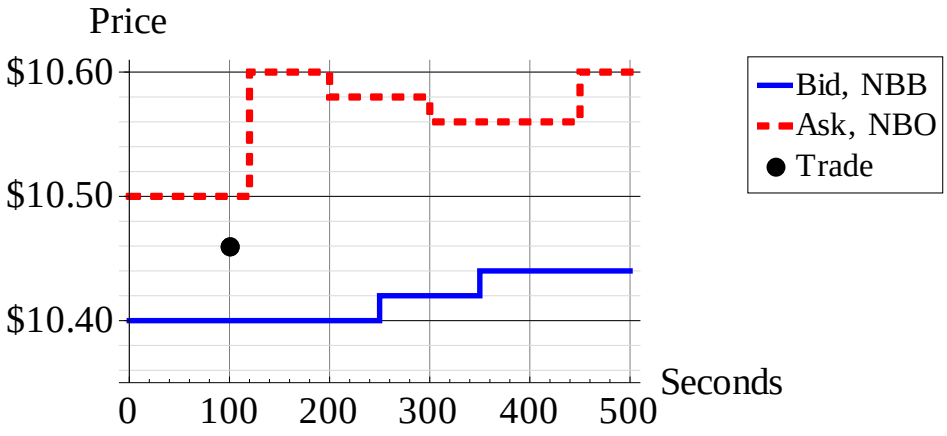
A buy order with price improvement



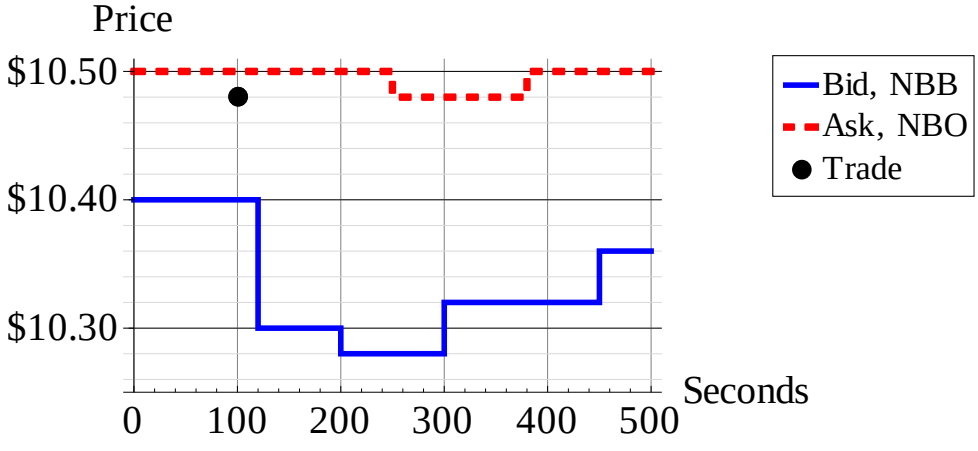
A sell order with price improvement



A more complicated buy order



A more complicated sell order



Extra: Sample problem

- The NBBO is 35.40 bid, offered at 35.50.
- A buy order is executed at 35.49.
- The NBBO five minutes later is 35.41 bid, offered at 35.55.
- Compute:
  - Price improvement
  - Effective cost
  - Realized cost
  - Price impact

Interpreting order/price impact

- "Price impact" is used in two senses.
  - Specific: for a given order, $effective\ cost - realized\ cost$ (the calculation described above).
  - General: the tendency for buy orders to cause a price rise, and for sell orders to cause a price drop.
    - A consequence of the (private) information inferred from the order.
- Price impact (in the general sense) is important in trading strategies where a larger order is split into smaller orders.
  - For a large buy order, the pieces that are executed in the beginning drive the price up for the pieces that are executed later.

Other implicit costs

- Explicit costs
  - Commissions, net of any rebates
  - Transactions taxes
- Implicit costs
  - Costs of interacting with the market (e.g., bid-ask or price impact costs), relative to the benchmark prices.
  - Opportunity costs (the penalty associated with not completing intended trades)
  - Delay (failure to accomplish the trade immediately)

Opportunity costs of failed execution attempts

- We want to buy. The make or take choice is:
  - Lift the offer immediately, or
  - Enter an order: buy limit $x < offer$
- Which will have the lowest IS relative to a pre-trade benchmark?
- As we make our order less aggressive ($\downarrow x$)
  - $IS = x - benchmark \downarrow$ *if the order is executed*.
  - But there's a lower chance of execution.

Ignoring opportunity costs for limit orders: the problem

- Suppose that the average spread in a stock is $0.10.
  - The half-spread is $0.05
- A hedge fund decides to try an experiment to measure order costs.
  - Submit 100 buy market orders.
  - Submit 100 buy limit orders priced at the bid.
- Compare average effective costs for each strategy.

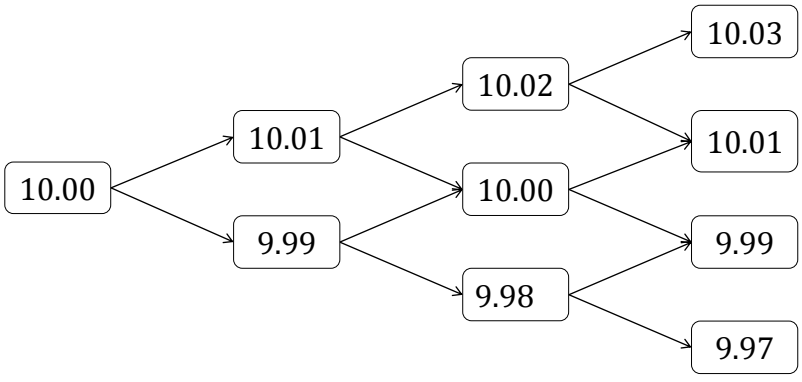
Outcome

- All of the market orders will execute, paying (on average) $0.05 above the midpoint.
  - Average effective cost = $0.05
- Some of the limit orders will execute. Those that *do* execute pay (on average) $0.05 *below* the midpoint.
  - Average effective cost = −$0.05
- Conclusion: “we should use more limit orders.”

Complication

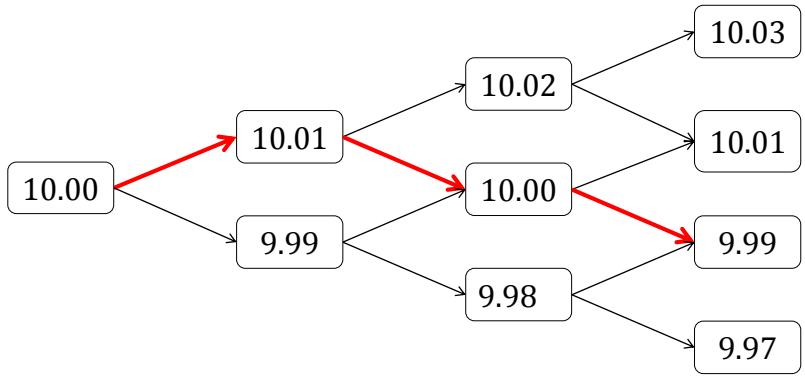
- Limit buy orders don't execute because the market price has moved up, and the limit order is left behind.
  - We don't buy stocks that subsequently go up in value.
  - This is costly: there is an opportunity cost for the failed executions.
- One approach to estimating the opportunity cost.
  - Assume that unexecuted limit orders are replaced at the end of the day by market orders.
  - We impute a fill at the closing price.
- The Tokyo Stock Exchange has a Funari order (a limit order that at the end of the day becomes a market on close order to any unexecuted portion).

Example: Fig 11.2 evolution of the offer price



This is a *binomial random walk model* of price dynamics. Over each "minute", there's an equal chance of $\pm$\$0.01 change. The binomial model is widely used in option valuation.

Offer price dynamics: probability calculations



- Each path has probability 1/8.
- An immediate market buy order pays 10.00
- We'll evaluate a limit order relative to the market order.

Analysis of buy limit order priced at 9.99

- If it executes we pay 9.99; if it doesn't, we'll have to use a final market order to complete the purchase.
- On 5 of the 8 paths, the order executes (we pay 9.99)
- On the remaining 3 paths, the order doesn't execute and we have to pay the end of day offer price.
  - On 2 paths we pay 10.01
  - On 1 path we pay 10.03
- On average, we pay $\frac{5}{8} \times 9.99 + \frac{2}{8} \times 10.01 + \frac{1}{8} \times 10.03$

$$= 6.24375 + 2.2025 + 1.25375 = 10.00$$

- This is the same as if we'd initially used a market order.

Summary

- If we assess limit orders using a pre-trade benchmark …
  - and only look at executions,
  - then limit orders seem to have great performance.
- With penalties for execution failures, limit orders don't look so great.
- In a random-walk model where we must execute at some point, limit orders are equivalent to market orders.
- This equivalence is not robust.
  - Minor changes in the setup can make limit orders a bit better or worse.

Delay

- When a large order is being worked over time, the price generally moves away from the order, even ignoring the price impact of the executions.
  - This increases the trading cost.
  - If we could have done the full trade immediately, we'd have avoided this cost.
- Example
  - Buy 10,000 shares split as 2,000 per hour over next five hours.
  - Over the five hours, the price tends to rise.
- By some estimates, the cost of delay is very high.

Why does the price move away from the order?

- Money managers complain:
  - The brokers handling our orders leak our intentions.
  - Other traders watching the market figure out ("sniff") what we're doing and buy ahead of us. Particularly the high-frequency traders.
- Another possibility
  - We usually think that we're the only ones who had the idea to buy in the first place.
  - What if other funds are watching the same indicators and putting in the same trades?

SEC Rule 605.

- A market center (any exchange or broker who executes orders) must report execution statistics.
  - These statistics must be reported on the market center's website.
- Compliance is usually minimal: the data are simply dumped in raw form.
- Interactive Brokers reports in an easy-to-understand layout.
  - *interactivebrokers.com → About IB → Performance Reports → … Monthly Rule 605 … Reports*
  - Next: stats for ticker symbol A (Agilent Technologies, November, 2013)

Symbol	Type	Size	Orders	Shares	CancShr	McExecShr	AwyExShr
A	Mrkt	100- 499	38	8326	0	8326	0
A	Mrkt	500-1999	14	9884	0	9884	0
A	mktL	100- 499	49	10262	0	10262	0
A	mktL	500-1999	9	8050	0	8050	0
A	mktL	2000-4999	1	2000	0	2000	0
AA	Mrkt	100- 499	281	48661	0	48661	0

- Mrkt - Market orders
- mrkL - marketable Limit Orders
- CancShr - Canceled Shares: Cumulative number of shares of covered orders canceled prior to execution.
- McExecShr - Market Center Executed Shares: Cumulative number of Shares of Covered Orders executed.
- AwyExShr - Away Executed Shares: Cumulative number of Shares of Covered Orders routed to another market by Interactive Brokers Ats and then executed.

Type	Size	Orders	Shares	ARS	AES	ImprShr	ImprAmnt
Mrkt	100- 499	38	8326	-0.0514	0.0154	3277	0.0100
Mrkt	500-1999	14	9884	-0.0384	0.0118	1000	0.0100
mktL	100- 499	49	10262	0.0438	0.0123	2358	0.0100
mktL	500-1999	9	8050	0.0941	0.0084	1300	0.0100
mktL	2000-4999	1	2000	-0.9300	0.0300	2000	0.0100

- ARS is the Average Realized Spread ($= 2 \times average\ realized\ cost$)
- AES is Average Effective Spread ($= 2 \times average\ effective\ cost$)
- ImpShr is Price Improved Shares: The cumulative number of shares of covered orders executed with price improvement
- ImpAmnt is (for the shares that had price improvement) the average price improvement ($/sh)

Analysis of market orders, 100-499 shares

- $Avg\ price\ improvement = \frac{3{,}277}{8{,}326} \times \$0.01 = \$0.0039$
- $Avg\ effective\ cost = \frac{\$0.0154}{2} = \$0.0077$
- Recall:
  - $Price\ improvement + effective\ cost = \frac{1}{2} \times bid/ask\ spread$
  - $Implied\ spread = 2 \times (\$0.0039 + \$0.0077) = \$0.0232$
- $Avg\ realized\ cost = -\frac{\$0.0514}{2} = -\$0.0257$
- $Avg\ price\ impact = effective\ cost\ - realized\ cost$
  $= \$0.0077 + \$0.0257 = \$0.0334$