Trading Cost Analysis & Order Execution Strategies

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Trading & Market Structure Analysis (TMA)

★ **Provide thought leadership and do innovative research on trading costs, order execution strategies and market structure**

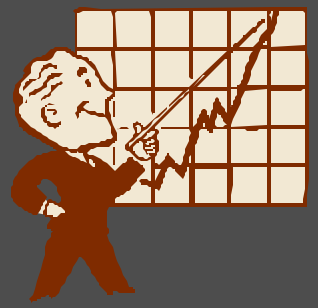
- Publish reports on trading costs and market structure
- Develop trading cost models and other pre-trade tools to help internal and external clients trade more efficiently
- Develop and popularize the right analytical framework and statistical methodology for trading cost comparisons
- Detailed execution quality analysis for key clients
- Help key clients choose among execution strategies

Goldman Sachs Best Execution Committee

- **Ensure Goldman is delivering good quality executions**
- **Evaluate Goldman order routing destinations**

Examples of reports

- **Liquidity at the NYSE before and after pennies**
- **The changing Nasdaq market and explicit fees**
- **Evaluating execution quality**
- **Choosing the best order execution strategy**



Overview

- Preliminaries
  - Introduction to trading cost analysis
  - Choice of order execution strategy
  - Types of liquidity
  - Displayed liquidity
  - Small and large order
  - Direct and indirect trading costs
- Small Orders
  - Quoted spreads
  - Effective spreads
- Large Orders
  - Implementation shortfall
  - Pre-trade cost
  - Execution shortfall
  - Liquidity impact
  - Deviations from VWAP
- How fast to execute?

Introduction to trading cost analysis

- Trading cost analysis is the use of past order execution data to
  - Analyze the factors influencing trading costs
  - Evaluate execution quality
  - Compare the costs of alternative strategies & execution venues
  - Estimate expected trading costs
  - Develop order execution strategies to minimize trading costs / maximize net returns

★ **A learning tool to better understand trading costs and improve execution quality**

The importance of trading cost analysis

A badly executed trade can negatively impact the performance of even the best idea. Trading cost analysis is a crucial part of the investment process.

Choice of order execution strategy

How to execute

- ★ **Fast or slow?** **Our focus**
- Agency or principal?
- Market or limit orders?
- Single-stock trades or program trades?
- Algorithmic or manual?

When to execute

Where to execute

- Exchanges
- Broker-dealers
- ECNs
- Crossing networks
- Direct access or through a broker-dealer
  - Value-added of broker-dealer

Trading cost analysis helps inform all these choices

Types of liquidity

Displayed

- NYSE book, ECNs
- Dealer quotes

Not-displayed at market venue

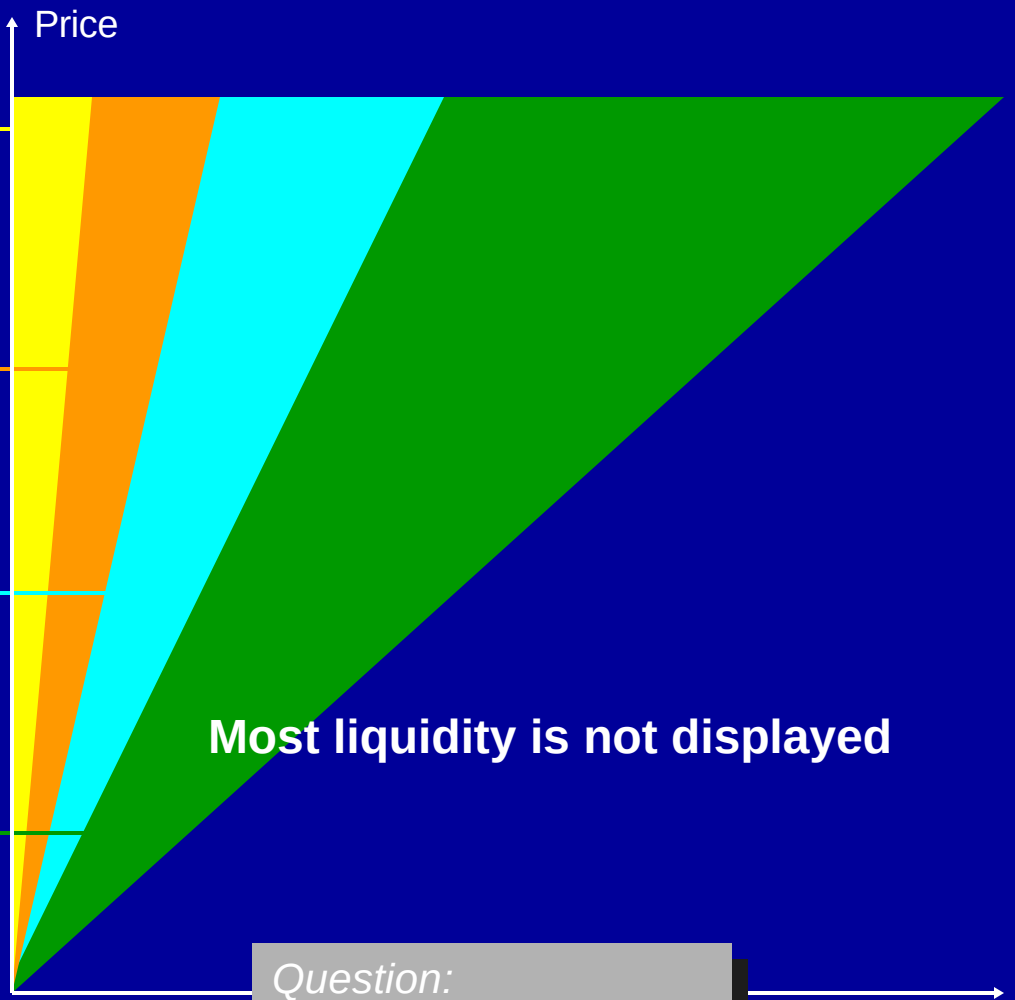
- NYSE floor brokers
- ECN reserve orders

Not-displayed at broker-dealers

- Agency orders held by brokers
- Not-displayed dealer liquidity

Not-displayed at investors

- Orders at buy-side desks
- "Latent" liquidity



Question:
Why is most liquidity not displayed?

1. Hypothetical; for illustration purposes only

Displayed liquidity

- Electronic limit order books
  - NYSE Display Book
  - Nasdaq SuperMontage
  - **ECNs**
  - SETS (London)
  - NSC (Paris)
  - Xetra (Frankfurt)
  - CATS (Toronto)
  - Many more…..
- Displayed priced (limit) orders
  - Aggregate at each price

DISPLAYED LIQUIDITY		
Buy Qty	**Price**	**Sell Qty**
	$25.46	1,100
	$25.45	1,200
	$25.44	1,000
	$25.43	1,500
	$25.42	**2,000**
2,000	**25.38**	
3,000	25.37	
1,200	25.36	
1,500	25.35	
800	25.34	

Small and large orders

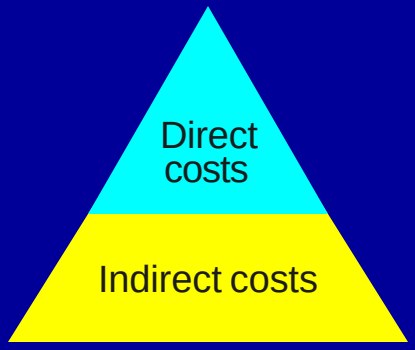
- Trading costs for small orders
  - Easy to measure
  - Easy to interpret
  - Easy to predict
  - Main measures
    - **Commissions**
    - **Quoted spreads**
    - **Effective spreads**
- Trading costs for large orders
  - Difficult to measure
  - Difficult to interpret
  - Difficult to predict
  - Main measures
    - **Commissions**
    - **Implementation shortfall**
    - **Deviations from VWAP**

Question:
When is an order small and when large?

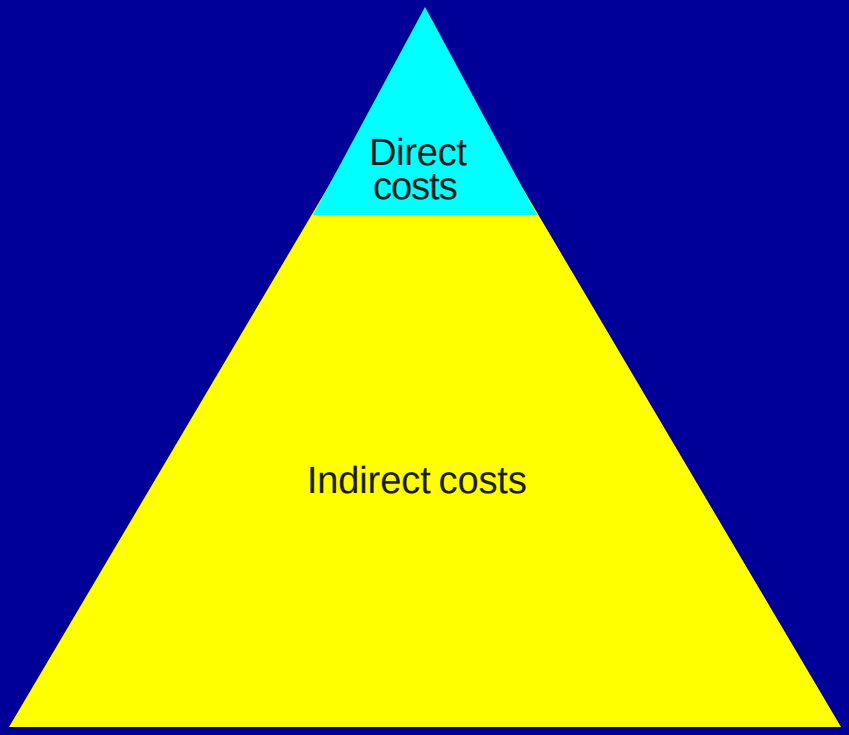
Direct and indirect trading costs

- Direct costs
  - Commissions
  - Easy to measure
  - Hard to interpret
- Indirect costs **Our focus**
  - Spreads, implementation shortfall, deviations from VWAP
  - Hard to measure, especially for large orders

Question:
Why are commissions hard to interpret?



Small orders



Large orders

Goldman Sachs

Small Orders

Quoted spreads

- **AlphaMax Advisors, Inc., a fictitious asset management firm, wants to buy 1,000 shares of XYZ**
- Best offer price
  - Lowest displayed price at which AlphaMax can buy
  - In our example: AlphaMax can buy XYZ at $25.42
- Best bid price
  - Highest displayed price at which AlphaMax can sell
  - In our example: AlphaMax can sell XYZ at $25.38
- Definition of quoted spread
  - **Difference between best bid and offer**
  - In our example: 4¢ or 16 bps *Question: bps?*
  - Roundtrip cost when AlphaMax buys at offer and sells at bid
  - Reward to liquidity providers
- Quoted spread applies up to quoted depth
  - In our example: 2,000 shares
  - AlphaMax will have to pay more for larger orders

DISPLAYED LIQUIDITY
Symbol XYZ

Buy Qty	Price	Sell Qty
	$25.46	1,100
	$25.45	1,200
	$25.44	1,000
	$25.43	1,500
	$25.42	**2,000**
2,000	**$25.38**	
3,000	$25.37	
1,200	$25.36	
1,500	$25.35	
800	$25.34	

Offer

Quoted spread

Bid

Effective spreads

- Because of not-displayed liquidity inside the quote, small orders may execute at price better than quote
  - Price improvement
  - In our example: AlphaMax bought 1,000 shares at $25.41
- Definition of effective spread
  - **Buy orders: execution price minus midquote, doubled**
  - In our example: 2¢ or 8 bps
  - Roundtrip cost of AlphaMax trade taking into account price improvement

Question:
What is the definition of effective spread for sell orders?

DISPLAYED LIQUIDITY
Symbol XYZ

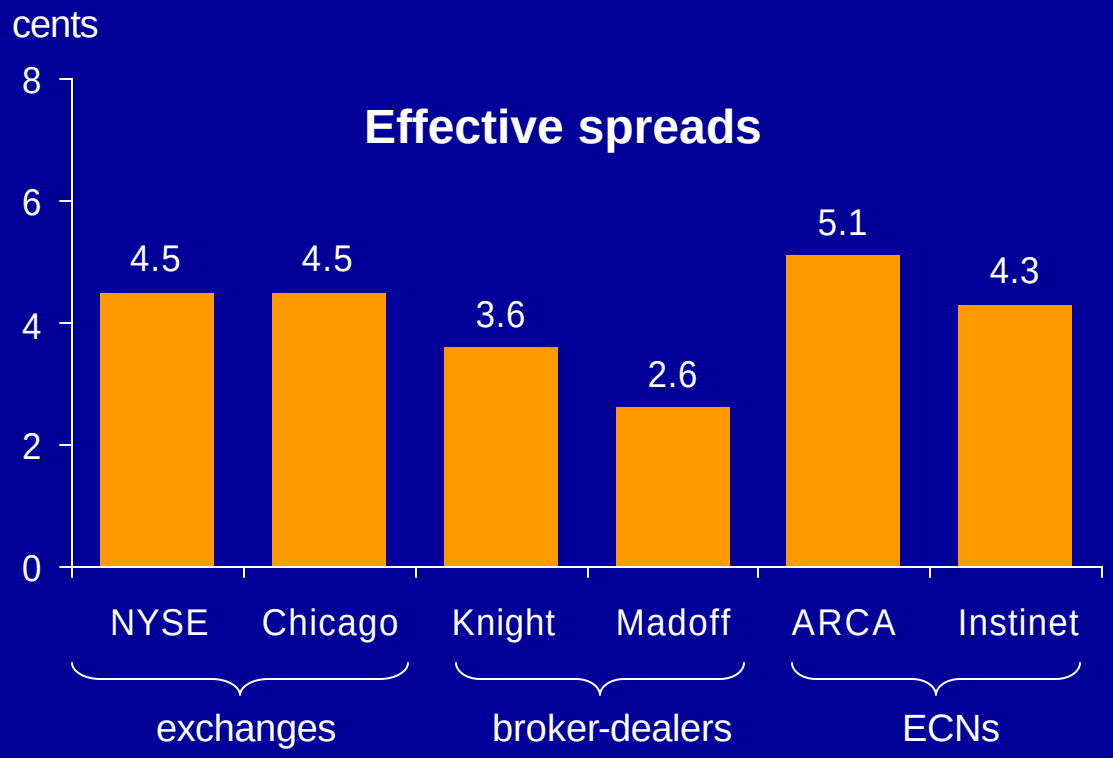
Buy Qty	Price	Sell Qty
	$25.46	1,100
	$25.45	1,200
	$25.44	1,000
	$25.43	1,500
	$25.42	**2,000**
	$25.41	
	$25.40	
2,000	**$25.38**	
3,000	$25.37	
1,200	$25.36	
1,500	$25.35	
800	$25.34	

Execution price

Midquote

Effective spreads at different venues

- SEC-mandated publicly available data
  - Rule 11Ac1-5
- Extremely useful
- But only for small orders
  - Less than 10,000 shares



NYSE "overlap" stocks
Market orders
500-1999 shares
August 2002
Selected venues

Question:
Why are the Knight, Madoff effective spreads so low?

Goldman Sachs

Large Orders

Walking up the book & not-displayed liquidity

- **Suppose AlphaMax wants to buy 600,000 shares of XYZ**
- Can start "walking up" the book using displayed liquidity
  - Buy 2,000 shares at $25.42
  - Buy 1,500 shares at $25.43
  - Buy 1,000 shares at $25.44
  - But 1,200 shares at $25.45
  - Etc
- Expensive
  - **Big liquidity impact**
- AlphaMax needs to access not-displayed liquidity and work order over time
  - AlphaMax "shops" order
  - AlphaMax finally sends order to an upstairs broker-dealer, Goldman Sachs, to work over the day

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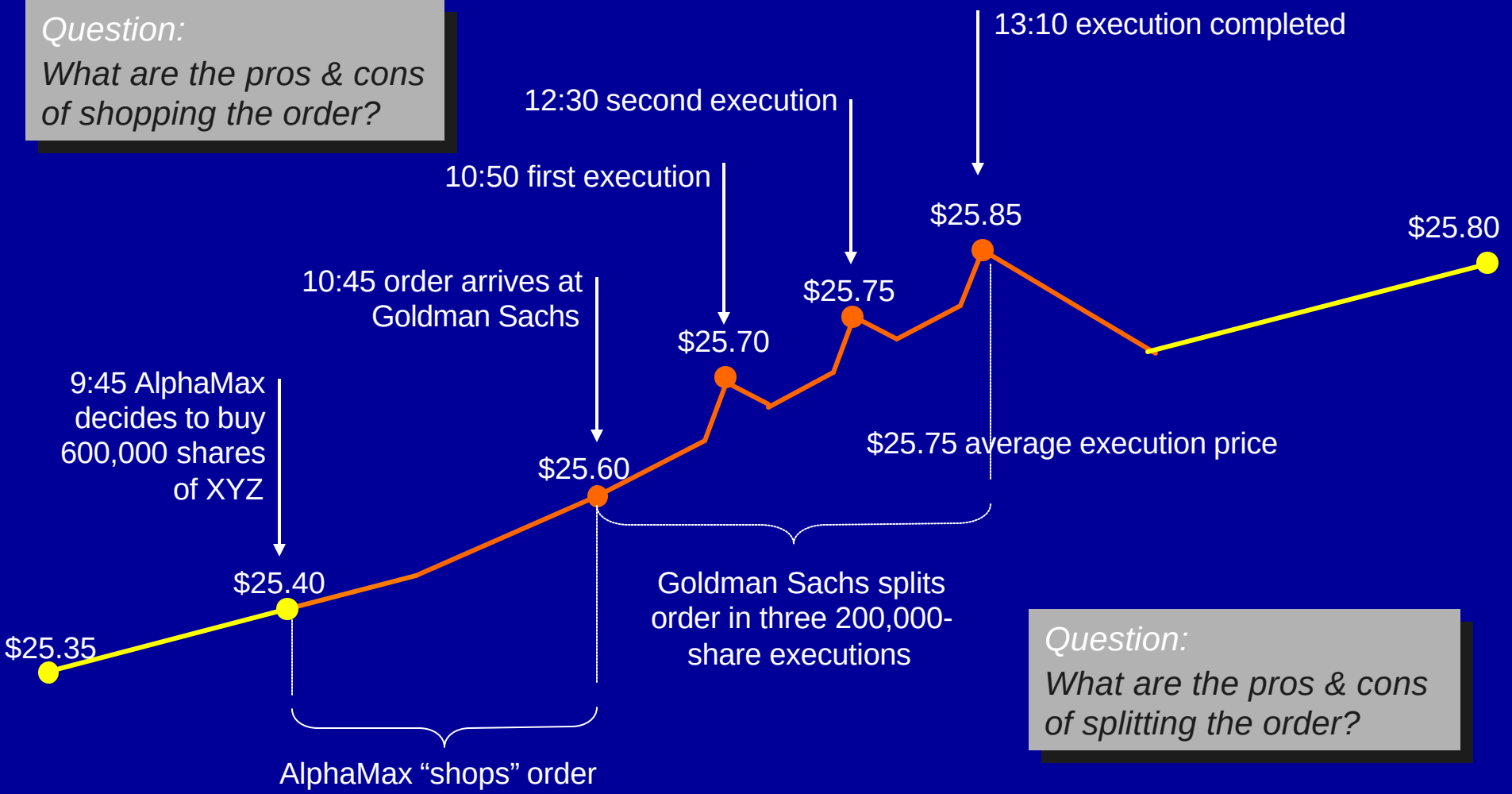
Profile of AlphaMax large buy order execution

Question:
What are the pros & cons of shopping the order?



Question:
What are the pros & cons of splitting the order?

Source: Goldman Sachs, Trading and Market Structure Research

Implementation shortfall

- Definition of Implementation Shortfall (IS)
  - **Buy orders: average execution price plus commissions minus price at investment-decision time**
- "All-in" trading cost from point of view of investor
  - Includes commissions, cost of shopping order, execution shortfall and opportunity cost of non-filled orders.

Source: Goldman Sachs, Trading and Market Structure Research

Pre-trade cost

- Definition of Pre-Trade Cost (PC)
  - **Buy orders: price when final execution venue receives order minus price at investment-decision time**
- Cost of shopping the order
  - Delayed execution
  - Information leakage

Question:
Who is responsible for the pre-trade cost?

Source: Goldman Sachs, Trading and Market Structure Research

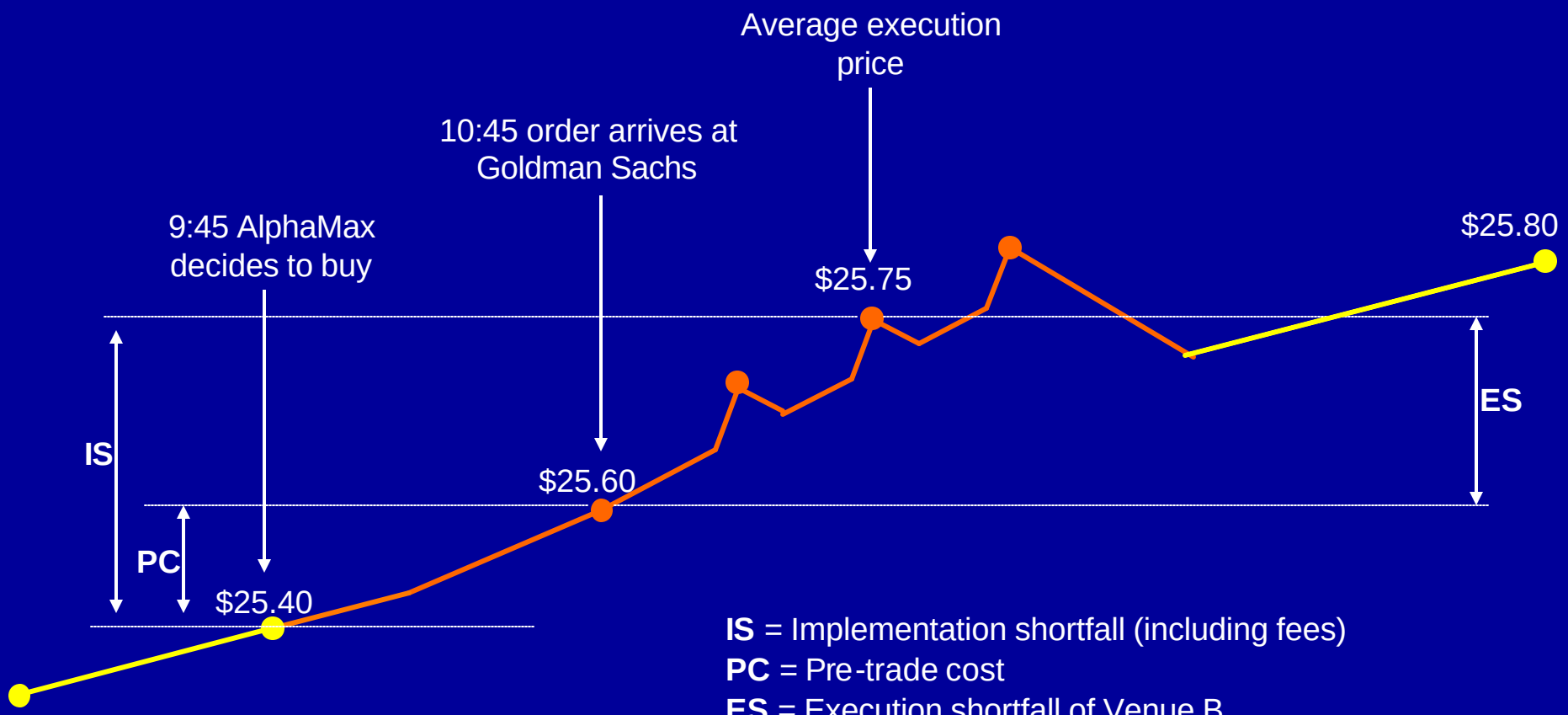
Execution shortfall

- Definition of Execution Shortfall (ES)
  - **Buy orders: average execution price minus price when execution venue receives order**
- Trading cost from point of view of executing venue
  - Executing venue is not responsible for pre-trade cost
  - Includes opportunity cost of slow execution

Question:
What are the differences between implementation and execution shortfall?

Source: Goldman Sachs, Trading and Market Structure Research

Putting it all together

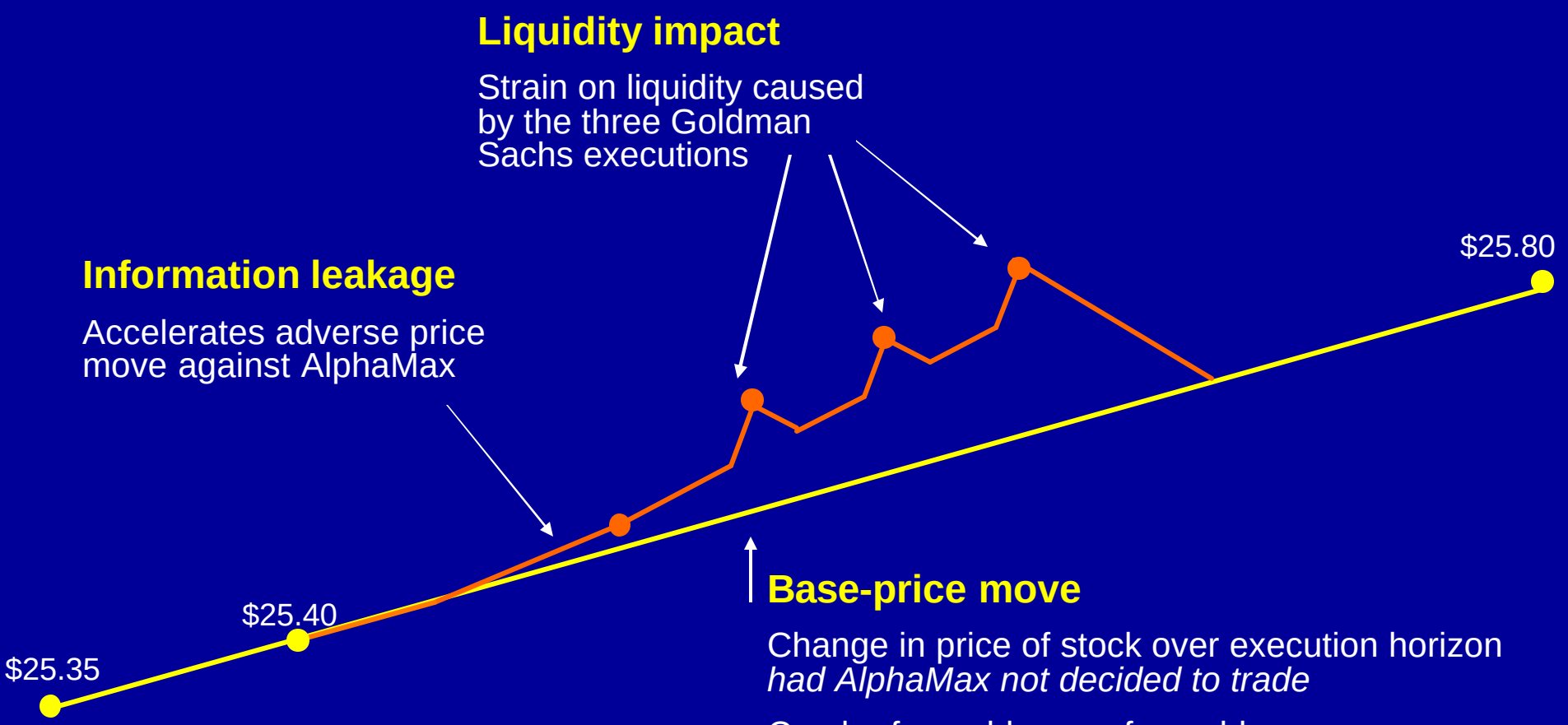


IS = Implementation shortfall (including fees)
PC = Pre-trade cost
ES = Execution shortfall of Venue B

IS = PC + ES + commissions

Source: Goldman Sachs, Trading and Market Structure Research

Factors affecting implementation shortfall



Liquidity impact

Strain on liquidity caused by the three Goldman Sachs executions

Information leakage

Accelerates adverse price move against AlphaMax

Base-price move

Change in price of stock over execution horizon *had AlphaMax not decided to trade*

Can be favorable or unfavorable

Not caused by AlphaMax or Goldman Sachs

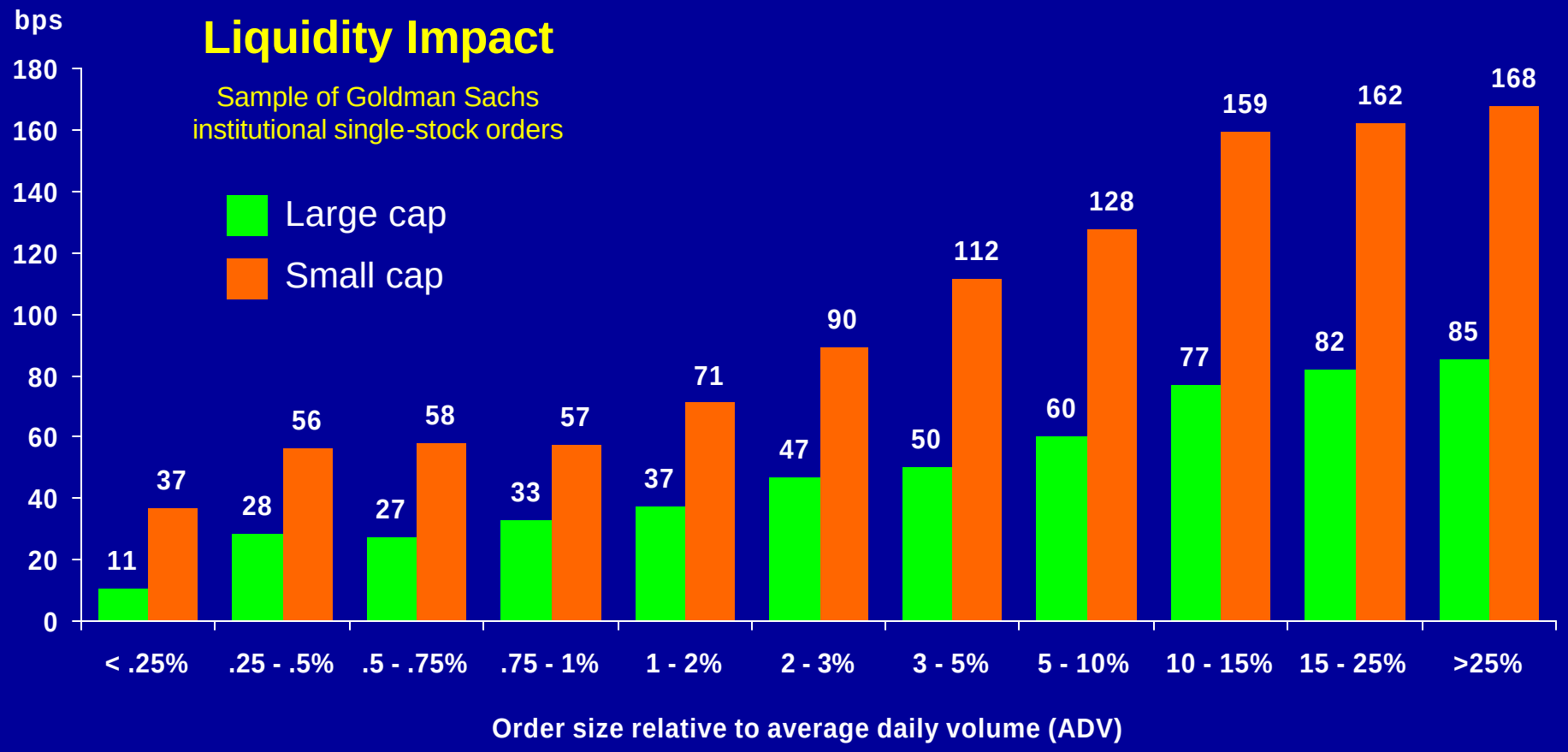
AlphaMax faces an unfavorable base-price move

Base-price changes create execution risk

Source: Goldman Sachs, Trading and Market Structure Research

Liquidity impact, order size and stock type

- Liquidity impact increases with order size
- A given order size has higher liquidity impact in small-cap stocks



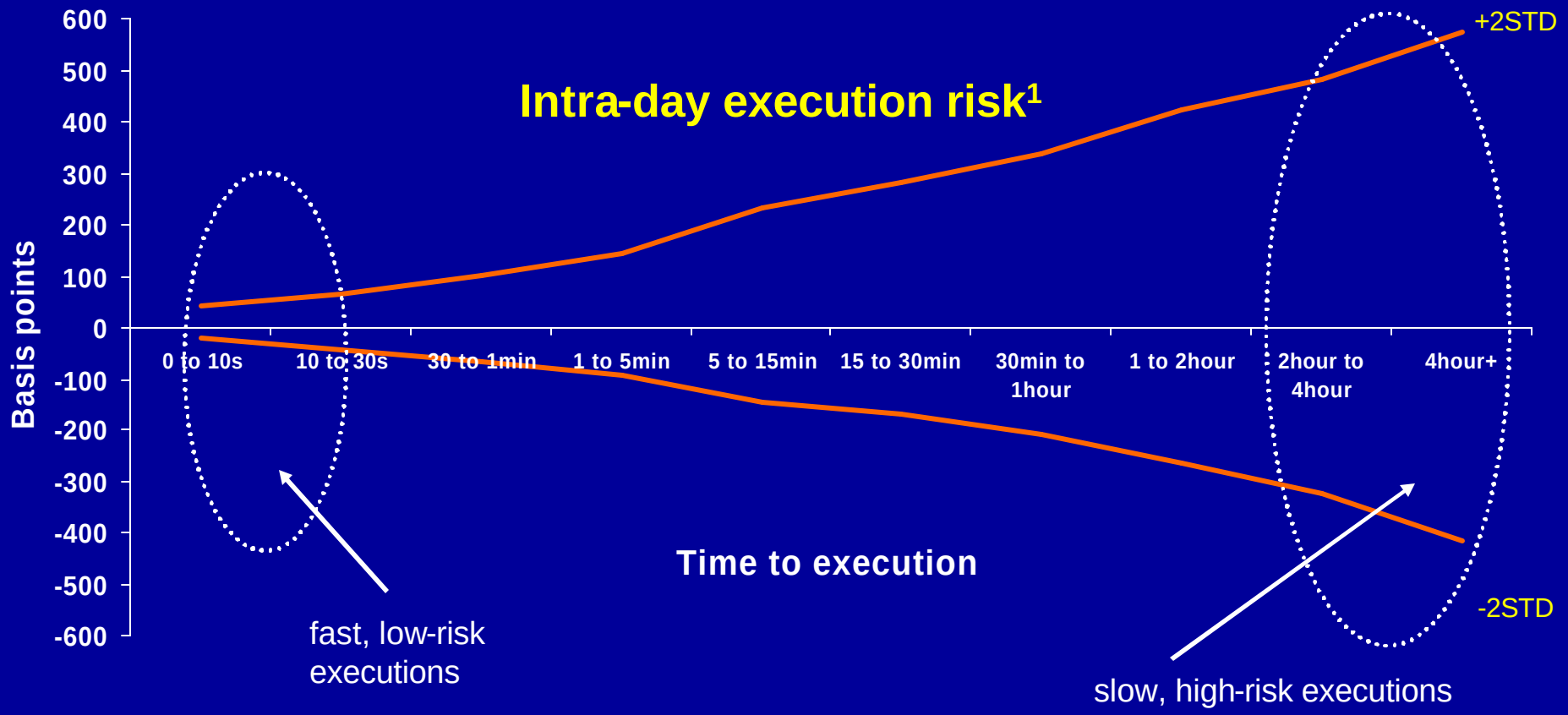
large cap = $10 billion or more; small cap = $1 billion or less

Execution risk

Question: **$$$$$**
How fast to execute?

- Slice-up order and execute over time to reduce liquidity impact
- Exposed to base-price moves and information leakage
- Execution risk increases sharply with time to execution

Trade-off



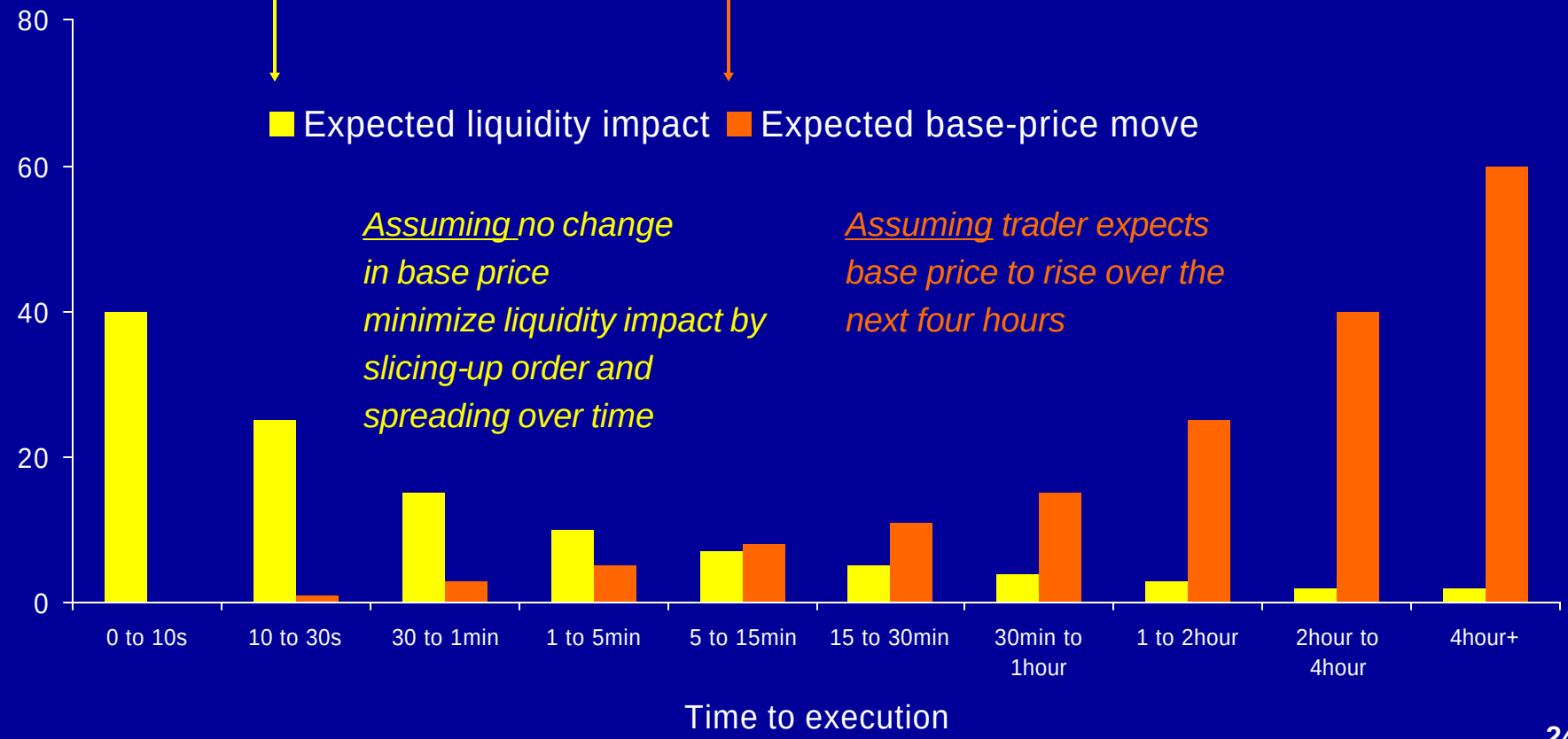
1. Sample of Goldman Sachs institutional not-held market orders, US Shares trading desk

How fast to execute?

Estimated from historical data highly predictable Easy to get

Hard to get
Trader's "feel for the market" extremely important

Broker-dealer value-added!



Assuming no change in base price minimize liquidity impact by slicing-up order and spreading over time

Assuming trader expects base price to rise over the next four hours