Fragmented markets and fast traders

Portfolio Construction

1 A story: the many market stalls

- One share, many places to trade
- Exchanges, trading systems, dark pools, dealers
- Competition lowers fees and spreads
- But the supply of shares is split into pieces

IN THE LESSON

- Imagine you must buy a huge pile of oranges.
- Long ago there was one market square, one crowd and one price.
- Today the same oranges are sold at stalls on several streets, in a back room where nothing is shown, and by a dealer from his own stock.
- No single stall holds enough.
- That is market fragmentation: the same security trading on many venues at the same time.
- Dana Whitfield faces exactly this with shares of Brightwater Foods.
- Competition between the venues is good, because it pushes fees and spreads down.
- But it also leaves the supply of shares in pieces, and the pieces are hard to gather.

2 Where one share can trade

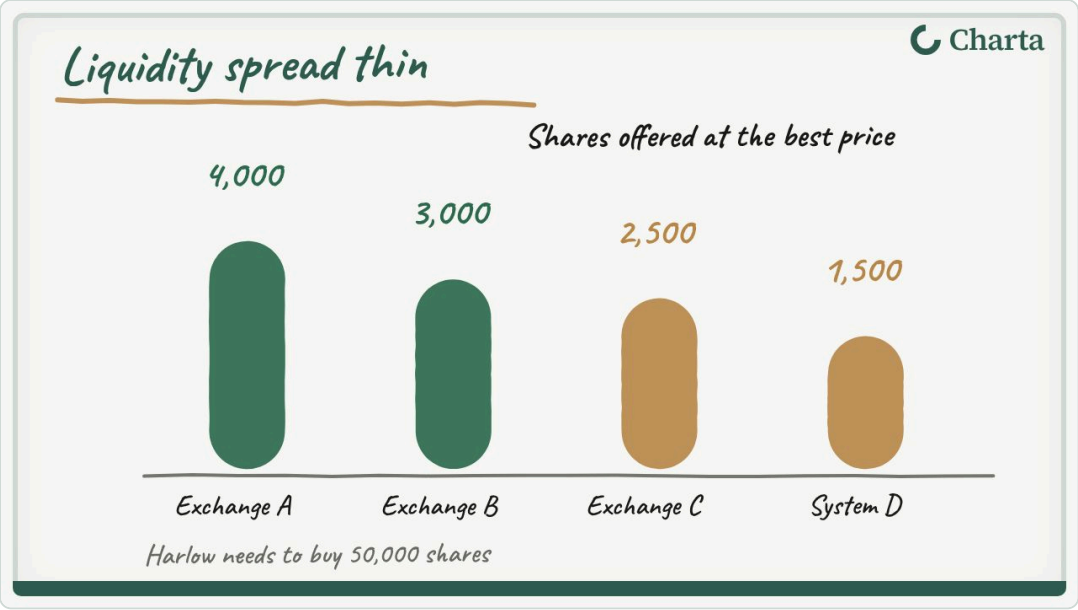
Where one share of Brightwater Foods can trade

Venue	Can others see it?
Exchange order book	Lit
Trading system	Mostly lit
Dark pool	Hidden
Dealer, own inventory	Private

IN THE LESSON

- Let us name the places.
- On the board are the main kinds of venue where a share of Brightwater Foods can trade.
- The exchange order book is the traditional one.
- Everyone can see its bids and offers, so we call it lit.
- A trading system, also called an alternative trading system, is a rival electronic market, and most of them are lit as well.
- A dark pool is different.
- Orders sit hidden there, and you learn about them only when a trade happens.
- Last, a dealer may fill an order from its own inventory, and nobody else sees that deal at all.
- Each place keeps its own queue of buyers and sellers.

3 Liquidity spread thin



IN THE LESSON

- Here is what Dana sees on her screens.
- The vertical axis is the number of shares offered at the best price, and each bar is one venue.
- Exchange A offers four thousand, the tallest bar.
- Exchange B offers three thousand, exchange C two thousand five hundred, and system D, a trading system, fifteen hundred.
- Now remember the size of her order, shown in the note under the picture: fifty thousand shares.
- Not one bar comes close.
- If she watched only exchange A, she would think the whole market offered four thousand shares.
- That is the classic trap.
- The quote on one screen is not all the liquidity there is, and the dark pools do not appear on this picture at all.

4 Example 1: how much can she see?

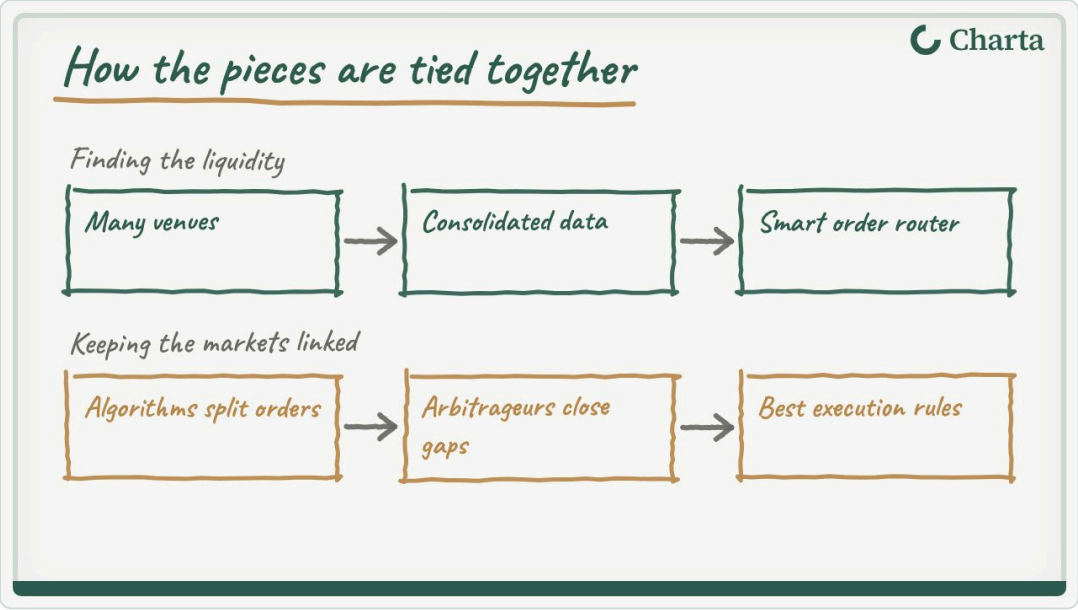
Buy 50,000 shares; best offers 4,000, 3,000, 2,500, 1,500

Largest venue alone	4,000 ÷ 50,000	**8%**
All four lit venues	4,000 + 3,000 + 2,500 + 1,500	**11,000**
Share of the order	11,000 ÷ 50,000	**22%**
Still to find	50,000 − 11,000	**39,000**

IN THE LESSON

- Let us put numbers on it.
- Dana must buy fifty thousand shares, and the four lit venues offer four thousand, three thousand, two thousand five hundred and fifteen hundred at the best price.
- The largest venue alone covers four thousand over fifty thousand, which is eight per cent of the order.
- Add all four lit venues and the total is eleven thousand shares, which is twenty two per cent.
- So even if she could hit every lit venue at once, the best price covers barely a fifth of the order.
- The rest, thirty nine thousand shares, must come from dark pools, from dealers and from patient trading over time.

5 How the pieces are tied together



IN THE LESSON

- If the market is in pieces, what holds it together?
- Look at the first row.
- Many venues each publish their own quotes.
- Consolidated data gathers those quotes into one view, so a trader can see the whole market.
- A smart order router then uses that view to send each order to the venue with the best price and depth.
- Now the second row, which keeps the venues linked.
- Algorithms split a big order into small parts, so it does not shout its size at one venue.
- Arbitrageurs buy where a share is cheap and sell where it is dear, which closes gaps between venues.
- And best execution rules require brokers to seek the best result for their clients.

6 What fragmentation does

Competition helps, but the pieces are small

Effect of fragmentation	Direction
Trading fees	Lower
Quoted spreads	Narrower
Depth at one venue	Thinner
Risk of stale prices	Higher

IN THE LESSON

- So is fragmentation good or bad?
- Both, and the table shows the balance.
- Competition between venues has made trading fees lower and quoted spreads narrower, and that helps every investor.
- But the depth at any one venue is now thinner, so the best price may be good for only a few shares.
- And prices on different venues can differ for a moment, which raises the risk of trading on a stale price, one that is out of date.
- For a large institutional order the result is plain.
- Routing choices matter far more than they did, and access to dark pools matters too.
- A small retail order barely notices.
- A very large order certainly does.

7 Example 2: the stale price

Router hits A first; fast traders then re-quote B

Fill at exchange A	4,000 × 40.02	**160,080**
Offer at B moves	40.02 → 40.05	**+0.03**
Fill at exchange B	3,000 × 40.05	**120,150**
Extra cost at B	3,000 × 0.03	**90**

IN THE LESSON

- Here is how slowness costs money.
- Dana's router hits exchange A first, and buys four thousand shares at forty point zero two, a total of one hundred and sixty thousand and eighty.
- But the router is not instant.
- Fast traders see that fill, guess that more buying is coming, and move the offer at exchange B from forty point zero two up to forty point zero five before her order arrives.
- She still wants three thousand shares there, and now pays forty point zero five.
- That is one hundred and twenty thousand, one hundred and fifty.
- Against the price she saw on screen, the extra cost is three thousand times three cents, ninety.
- Small here, but it grows with size.
- Sending all the orders at the same moment avoids it.

8 A story: the cast of the market hall

- Electronic dealers post bid and ask quotes
- Arbitrageurs and news traders keep prices right
- Buy-side algorithms trade big orders cheaply
- Front runners and quote matchers feed on big orders

IN THE LESSON

- Picture a busy market hall at closing time.
- Some people stand ready to buy from or sell to anyone, and charge a small fee for it.
- Some run between stalls spotting gaps in prices.
- Some read the news the second it lands.
- And some watch for a big shopper, and dash ahead to buy first.
- Electronic markets have the same cast, only much faster.
- Dana Whitfield needs to know who might be on the other side of her trades, because some of them improve prices, and some live off slower participants.
- The kinds that matter are electronic dealers, arbitrageurs, news traders, buy side algorithms, front runners and quote matchers.

9 Kinds of electronic trader, part one

Four kinds of electronic trader

Kind	What it does
Electronic dealer	Posts bid and ask
Arbitrageur	Trades price gaps
News trader	Trades on releases
Buy-side algorithm	Splits big orders

IN THE LESSON

- Start with the first four.
- An electronic dealer, also called a market maker, posts a bid and an ask at the same time and earns the difference, the spread.
- An arbitrageur looks for the same thing priced differently in two places, or for two linked products out of line, buys the cheap one and sells the dear one, and so pulls prices together.
- A news trader reacts within moments of an information release, such as an earnings figure, and so moves prices to their new level quickly.
- The buy side trader is Dana and her colleagues.
- They use algorithms to execute big institutional orders at low cost by splitting them up.

10 Kinds of electronic trader, part two

Two that feed on big orders

Kind	What it does
Front runner	Trades ahead of you
Quote matcher	Bids just inside you
What both need	Your order is visible

IN THE LESSON

- Now the two that worry institutions.
- A front runner tries to detect a large order on its way, and trades ahead of it.
- If Dana's buying is about to push the price up, the front runner buys first and sells to her at the higher price.
- A quote matcher places an order just inside a large visible order, for example one tick above her bid.
- If the price rises, the matcher gains.
- If the price falls, it sells to her large bid and loses very little.
- In both cases, the trader needs one thing: a large order that others can see, or can guess.
- Hiding and splitting her order is her main defence.

11 Who helps and who takes



IN THE LESSON

- Let us place all six on one line.
- The left end is the part of fast trading that helps other investors, and the right end is the part that takes from slower ones.
- On the left, electronic dealers narrow spreads by competing to post quotes.
- Arbitrageurs keep prices lined up across venues.
- News traders push prices to their right level quickly.
- In the middle sits the buy side algorithm, which is Dana herself, simply trying to get an order done cheaply.
- Further right are quote matchers, who use somebody else's order as a free option.
- At the far right are front runners, who profit only by getting in front.
- The lesson is not that fast trading is bad.
- It is that kinds differ.

12 Example 3: how a dealer earns

Dealer quotes 39.98 bid, 40.02 ask; trades 1,000 shares each way

Quoted spread	40.02 − 39.98	**0.04**
Bought 1,000 at the bid	1,000 × 39.98	**39,980**
Sold 1,000 at the ask	1,000 × 40.02	**40,020**
Dealer earns	40,020 − 39,980	**40**

IN THE LESSON

- Here is the dealer's business in numbers.
- A dealer quotes a bid of thirty nine point nine eight and an ask of forty point zero two.
- The quoted spread is the difference, four cents.
- In one busy minute it buys one thousand shares from sellers at the bid, paying thirty nine thousand, nine hundred and eighty, and sells one thousand shares to buyers at the ask, receiving forty thousand and twenty.
- The gain is forty.
- That does not sound like much, but multiply it by thousands of trades, in hundreds of stocks, every day.
- Competition among dealers pushes the spread down, which is why this kind of fast trader often helps Dana, rather than hurting her.

13 Example 4: the quote matcher's free option

Harlow bids 50,000 at 40.00; matcher bids 1,000 at 40.01

Price rises to 40.20	(40.20 − 40.01) × 1,000	**190**
Bad news: sells at 40.00	(40.01 − 40.00) × 1,000	**−10**
Gain against risk	190 ÷ 10	**19 to 1**

IN THE LESSON

- Now the quote matcher.
- Dana's fund shows a bid for fifty thousand shares at forty point zero zero.
- A matcher places its own bid for one thousand shares at forty point zero one, just inside hers, and is filled.
- If good news arrives and the price rises to forty point two zero, the matcher sells at the higher price, and gains nineteen cents a share, one hundred and ninety in total.
- If bad news arrives, the matcher sells to Dana's bid at forty, and loses one cent a share, ten in total.
- So it risks ten to make one hundred and ninety.
- That is nineteen to one.
- In effect, Harlow wrote a free option for a stranger, and lost out in the good case too, because the matcher jumped her in the queue.

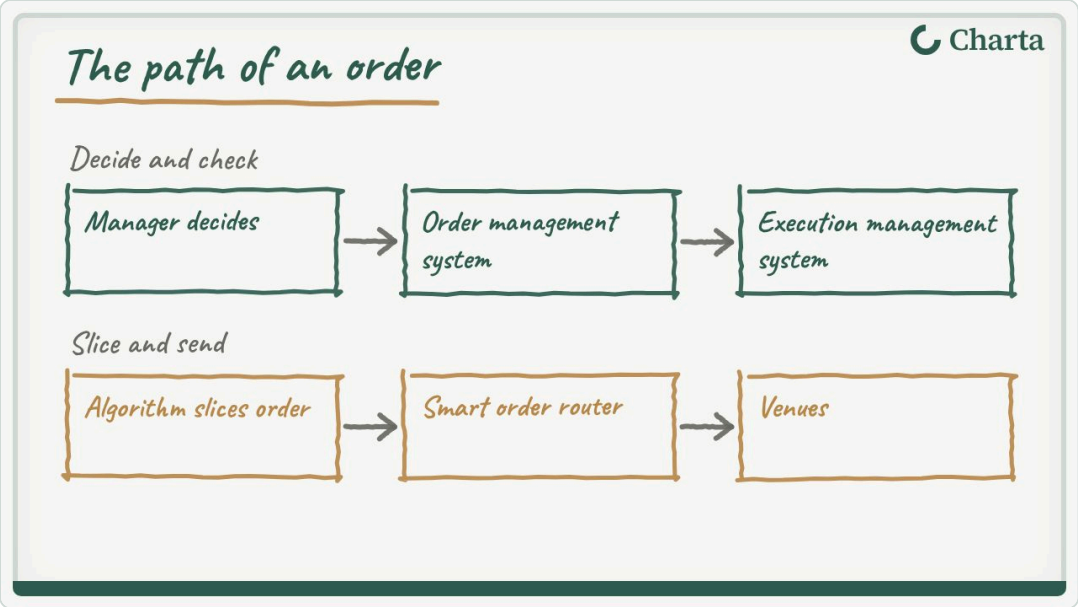
14 A story: the parcel that finds its van

- Order management system records and checks
- Execution system hands the order to an algorithm
- Algorithm slices parent order into child orders
- Smart router picks the venue for each slice

IN THE LESSON

- Think of a courier firm.
- A parcel is logged at the desk, checked against the rules, split across several vans, and each van is sent along the best road.
- A portfolio manager's order travels the same way.
- The order management system records the order and checks it against the portfolio's rules.
- The execution management system hands it to an algorithm.
- The algorithm slices the large parent order into many small child orders.
- A smart order router then picks the venue for each slice.
- Dana's job is not to build these systems.
- It is to decide how the chain should behave for each order.

15 The path of an order



IN THE LESSON

- Follow the order along the two rows.
- First row.
- Dana decides to buy, and that decision enters the order management system, which records it and checks the portfolio rules.
- The execution management system takes the order and chooses how to work it.
- Second row.
- A trading algorithm slices the order into child orders and releases them over time.
- Each child goes to the smart order router, which sends it to the venue with the best price and depth at that moment.
- The last box is the set of venues, and it includes exchange order books, alternative trading systems and crossing networks, which match buyers and sellers at a reference price such as the midpoint of the bid and the ask.

16 Three common algorithms

How algorithms schedule an order

Algorithm	Trades
VWAP	Follows daily volume
Percent of volume	Fixed share of volume
Implementation shortfall	Weighted to the start

IN THE LESSON

- The algorithm is where most of the judgement sits.
- A V W A P algorithm, short for volume weighted average price, spreads an order across the day in proportion to the usual volume pattern, and aims to match the day's average price.
- A percent of volume algorithm trades a fixed share of whatever volume appears, so it speeds up when the market is busy and slows down when it is quiet.
- An implementation shortfall algorithm is built to minimise the gap between the decision price and the final result, so it trades more at the start, accepting more market impact now to reduce the risk that the price drifts away later.
- Patient algorithms cost little impact.
- Urgent ones cost more.

17 Order types and access

Tools for hiding and reaching

Tool	What it does
Hidden order	Not displayed
Iceberg order	Shows a small slice
Pegged order	Follows a reference price
Direct market access	Own order to the venue

IN THE LESSON

- Algorithms use special order types and access routes.
- A hidden order is not displayed to the market at all.
- An iceberg order shows only a small slice of its true size, and refills the slice each time it is filled, like the tip of an iceberg above the water.
- A pegged order moves automatically with a reference price, such as the midpoint.
- And direct market access lets a buy side firm send its own order straight into a venue through a broker's connection, without the broker's trader in between.
- Each tool is a way to manage the same trade off: showing less protects an order from front runners, but also makes it less likely to be found by a seller.

18 Example 5: how fast should she trade?

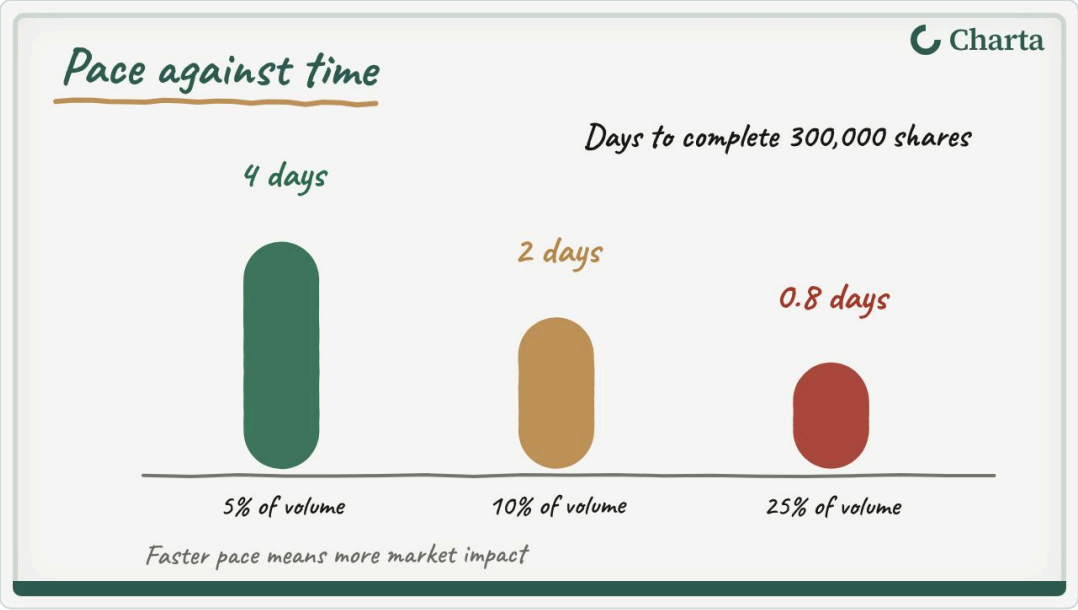
Buy 300,000 shares; average daily volume 1,500,000

Order as share of a day	300,000 ÷ 1,500,000	**20%**
At 10% of volume	300,000 ÷ 150,000	**2 days**
At 25% of volume	300,000 ÷ 375,000	**0.8 days**
Her choice, no urgency	10% of volume	**2 days**

IN THE LESSON

- Now a decision.
- Harlow must buy three hundred thousand shares of a company as part of a routine rebalancing, and Dana has no special information.
- The stock trades one million five hundred thousand shares on an average day, so the order is twenty per cent of a day's volume.
- Big enough to move the price if pushed.
- If her algorithm takes ten per cent of volume, that is one hundred and fifty thousand shares a day, so the order takes two days.
- At twenty five per cent of volume, that is three hundred and seventy five thousand a day, so it takes less than a day, point eight of a day.
- Since the order is not urgent, she picks ten per cent, and pays for patience, not for speed.

19 Pace against time



IN THE LESSON

- Here is the same trade off as a picture.
- The vertical axis is the number of days to complete the three hundred thousand shares, and each bar is one participation rate.
- At five per cent of volume the order takes four days, the tallest bar.
- At ten per cent it takes two days.
- At twenty five per cent it takes eight tenths of a day.
- So a higher rate gets the job done sooner.
- The note under the picture tells the other half of the story: the faster the pace, the more market impact.
- It also tells us when to go quickly.
- If the manager expects news that others will soon act on, the cost of waiting grows, and an implementation shortfall algorithm becomes the right choice.
- Without that, patience wins.

20 Match the tool to the order

Which tool for which order

Order	Tool
Routine rebalance	VWAP or 10% of volume
Urgent, news-driven	Implementation shortfall
Large, keep it quiet	Iceberg, dark pool
Small, liquid stock	Smart order router

IN THE LESSON

- Let us turn this into a rule of thumb.
- If the order is a routine rebalancing, large but not urgent, use V W A P or a low participation rate.
- If it is driven by news and delay is expensive, use implementation shortfall and accept the impact.
- If the order is large and you want to keep it quiet, use iceberg orders and dark pools.
- And if it is small and the stock is liquid, a smart order router sending it straight to the best price is enough.
- The trap, and a favourite one for the exam, is using an aggressive algorithm on a patient order.
- That pays for urgency the order does not have, and it shows your hand to fast traders.

21 Mistakes to avoid so far

- Treating one venue's quote as all the liquidity
- Treating all fast trading as harmful
- Using an aggressive algorithm on a patient order
- Showing a large order in full on a lit venue
- Forgetting that dark pools show nothing until a trade

IN THE LESSON

- Let us collect the common mistakes from the first three topics.
- One: treating the quote on one venue as all the liquidity there is.
- Two: treating all fast trading as harmful, when dealers and arbitrageurs often narrow spreads.
- Three: using an aggressive algorithm on a patient order.
- Four: showing a large order in full on a lit venue, where front runners and quote matchers can see it.
- Five: forgetting that dark pools show nothing until a trade happens, so the liquidity may be there without being seen.
- If you remember those five, you will avoid most of the traps that appear in questions on this part of the syllabus.

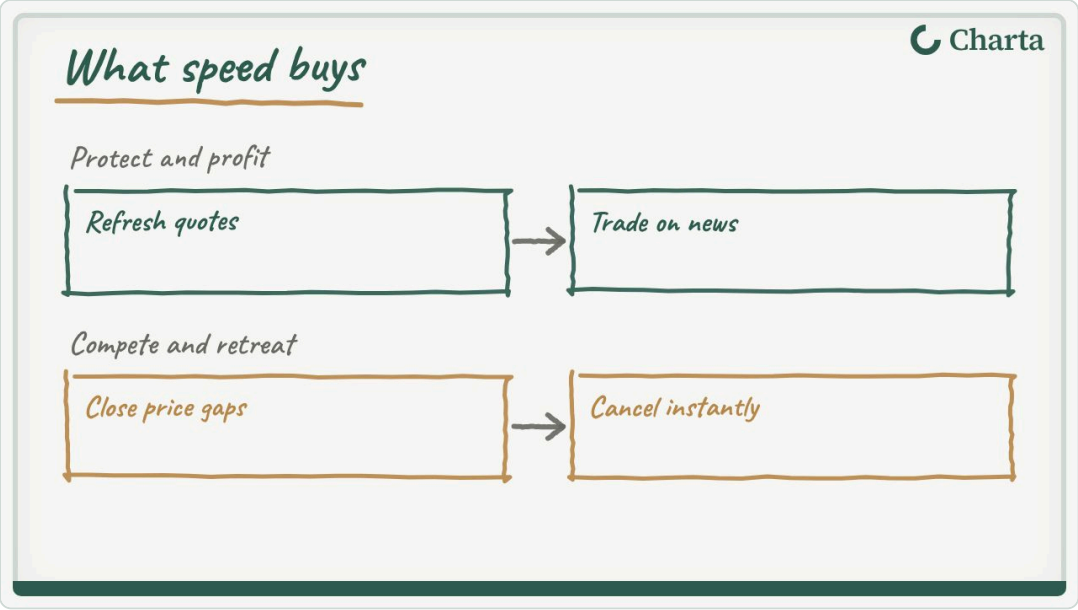
22 A story: the first one to the dock

- Latency is the delay between event and reaction
- Low-latency traders act in microseconds
- Co-location and direct data feeds buy that speed
- Speed is used in four ways

IN THE LESSON

- At a fishing port, the boat that lands first sees the whole catch, and can buy the best fish before the others even arrive.
- In electronic markets, the same advantage is measured in microseconds, which are millionths of a second.
- Latency is the delay between an event and a trader's reaction to it.
- Low latency traders cut that delay by placing their servers right beside the exchange's matching engine, which is called co-location, and by buying direct data feeds.
- They are not smarter.
- They are earlier.
- Dana Whitfield needs to know what that earliness buys them, and who pays for it.

23 What speed buys



IN THE LESSON

- Each box is the same advantage, speed, used in a different way.
- First row.
- A dealer that can refresh its quotes the instant prices start to move is rarely left with a stale quote for an informed trader to hit, and that is what lets it quote tighter spreads.
- A fast trader can also react to news before prices adjust.
- Second row.
- A fast trader can spot a tiny price difference between two venues and trade it away before it disappears, which closes price gaps.
- And it can cancel or change an order instantly when conditions change.
- Notice the pattern.
- Most of these uses profit from being first, and whoever is slower ends up on the other side.
- A large order, visible and worked over hours, is often that slower participant.

24 What a dealer must charge

Break-even half-spread = P(informed) × loss per informed trade
Quoted spread = 2 × half-spread

Half-spread	Earned on every share traded
Chance informed	Share of trades that are informed
Loss per informed trade	Price move against the dealer

IN THE LESSON

- To see why speed can make trading cheaper, we need one rule.
- A dealer earns the half spread on every share it trades, which is half the gap between its bid and its ask.
- But some trades are with better informed counterparties, and after those the price moves against the dealer by a known amount.
- To break even, the half spread must be at least the chance that a trade is informed, times the loss on an informed trade.
- The quoted spread is then twice the half spread.
- Reduce the chance of being picked off, and the spread can narrow.
- That is exactly what a fast dealer does, by cancelling stale quotes in time.

25 Example 6: slow dealer, fast dealer

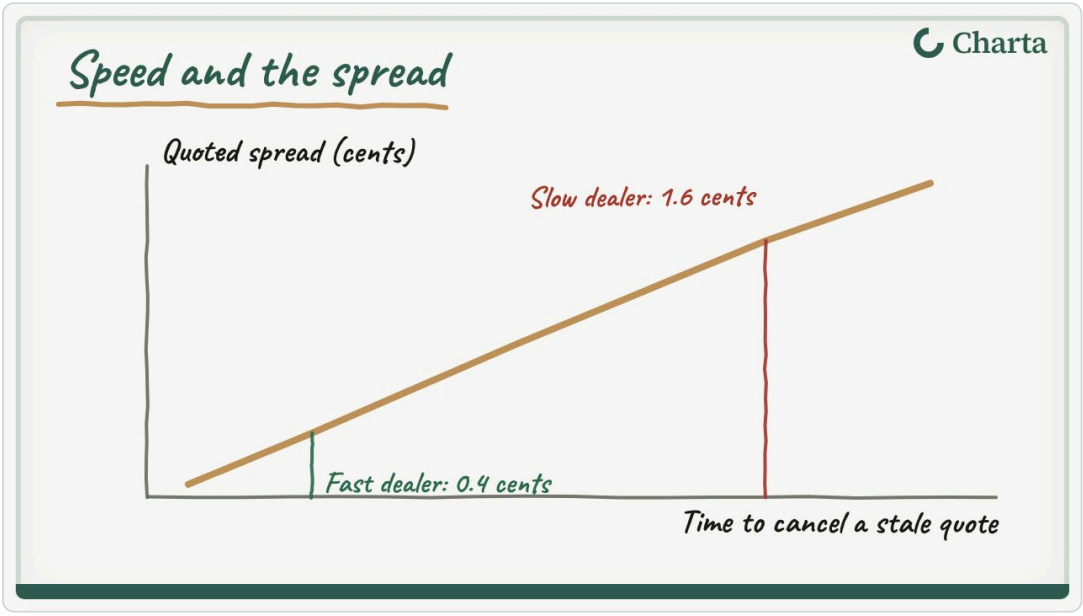
Informed trade costs 4 cents; slow 20% informed, fast 5%

Slow dealer, expected loss	20% × 4 cents	**0.8 cents**
Slow dealer, spread	2 × 0.8 cents	**1.6 cents**
Fast dealer, expected loss	5% × 4 cents	**0.2 cents**
Fast dealer, spread	2 × 0.2 cents	**0.4 cents**

IN THE LESSON

- Let us compare two dealers in an illustrative market.
- An informed trade costs either dealer four cents a share.
- The slow dealer is hit by informed traders on twenty per cent of its trades.
- Its expected loss is twenty per cent of four cents, point eight of a cent a share, so its quoted spread is twice that, one point six cents.
- The fast dealer can cancel stale quotes in microseconds, so only five per cent of its trades are with informed traders.
- Its expected loss is point two of a cent, and its spread is point four of a cent, a quarter as wide.
- Speed has cut the dealer's risk, and the saving passes to every investor who trades with it.

26 Speed and the spread



IN THE LESSON

- Here are the two dealers on one picture.
- The horizontal axis is the time a dealer takes to cancel a stale quote, short on the left and long on the right.
- The vertical axis is the quoted spread in cents.
- Now the curve.
- The slower the dealer is, the more often it is picked off, so the spread it must charge climbs.
- Look at the labelled points.
- The fast dealer sits low on the left, charging point four of a cent.
- The slow dealer sits high on the right, charging one point six cents.
- So in normal markets, low latency market making usually lowers the cost of trading.
- But the same chart hides something.
- Speed that helps in calm times can be switched off just as quickly.

27 How institutions protect themselves

Defences against being read

Risk to Harlow	Defence
Big order detected	Hide: iceberg, dark pool
Pattern predicted	Randomise size and timing
Stale price at a venue	Fast router, live data
Sheer scale of order	Slower, patient schedule

IN THE LESSON

- What should Dana do about all this?
- The table lists the defences.
- If a large order is detected, hide it with iceberg or hidden orders and use dark pools, so fast traders cannot see its size.
- If its pattern could be predicted, randomise the sizes and timing of the child orders, so a trader cannot learn a schedule.
- If a venue shows a stale price, use a fast router and live data, so that her orders arrive together.
- And for sheer scale, a slower, more patient schedule gives the order less footprint on the market.
- Notice that all of these are algorithms and choices, not a race.
- The institution does not need to be faster than the fast traders.
- It needs to be harder to read.

28 Example 7: the trap in a storm

Calm day against stress day, depth at the best price

Calm day, four venues	4,000+3,000+2,500+1,500	**11,000**
Stress day, quotes pulled	1,000+300+200+0	**1,500**
Depth lost	11,000 − 1,500	**9,500**
Share of order showing	1,500 ÷ 50,000	**3%**
Fall in depth	9,500 ÷ 11,000	**86%**

IN THE LESSON

- Now the other side of the coin, and a favourite exam trap.
- It is wrong to assume that fast traders always add liquidity.
- In normal markets they usually do.
- In stress, they can withdraw quickly.
- Here is an illustration with Harlow's fifty thousand share order.
- On a calm day the four venues offer eleven thousand shares at the best price.
- In a storm, the dealers pull their quotes, and only one thousand, three hundred, two hundred and nothing remain, fifteen hundred in all.
- That is nine thousand five hundred shares lost, eighty six per cent of the depth.
- Only three per cent of her order is now showing.
- Dana must plan for it: lower the pace, and never count on the depth that was there yesterday.

29 Recap: the lesson in five lines

- Fragmentation: many venues, thin depth, routing matters
- Dealers help; front runners and quote matchers take
- Order, algorithm, router: match pace to urgency
- Speed narrows spreads in calm markets
- In stress, fast liquidity can vanish

IN THE LESSON

- Let us pull the lesson together.
- First, fragmentation means one share trades on many venues, so depth at any one venue is thin, and routing and dark pool access matter.
- Second, among the electronic traders, dealers, arbitrageurs and news traders often improve prices, while front runners and quote matchers live off big orders that others can see.
- Third, an order passes through order systems, algorithms and routers, and the manager must match the algorithm to the order's urgency and size.
- Fourth, speed lets dealers cut their losses and quote tighter spreads.
- Fifth, the same speed lets others trade ahead of slow orders, and in a storm that liquidity can vanish.

30 Try three quick questions

1. Order 20,000; lit venues offer 2,000, 1,500, 1,000. Share covered?
   Answer: 4,500 ÷ 20,000 = 22.5%.
2. Matcher bids 500 at 20.01, large bid 20.00. Price rises to 20.11. Gain? Loss?
   Answer: (20.11 − 20.01) × 500 = 50; loss (20.01 − 20.00) × 500 = 5.
3. Informed trade costs 5 cents; 10% of trades informed. Spread?
   Answer: Half-spread 10% × 5 = 0.5 cents; spread = 2 × 0.5 = 1.0 cent.

IN THE LESSON

- Now try three quick questions yourself.
- Pause after each one.
- Question one.
- A buyer needs twenty thousand shares.
- Three lit venues offer two thousand, fifteen hundred and one thousand at the best price.
- What share of the order do they cover?
- Together they offer forty five hundred, and forty five hundred over twenty thousand is twenty two point five per cent.
- Question two.
- A quote matcher bids for five hundred shares at twenty point zero one, just inside a large bid at twenty.
- The price rises to twenty point one one.
- What does it gain, and what does it lose if it must sell to the large bid?
- It gains fifty, and loses five.
- Question three.
- A dealer loses five cents on an informed trade, and ten per cent of its trades are informed.
- What spread does it need?
- Its half spread is half a cent, so its spread is one cent.
- Well done, you can move on.