CHARTA LEARNING · LESSON NOTES

How exchange traded funds work

Portfolio Management

1 A story: the two doors

- Front door: the exchange, the secondary market
- Back door: the fund itself, the primary market
- Only authorised participants use the back door
- Investors do not create or redeem shares

IN THE LESSON

- Picture a big shop with two doors.
- The front door is where customers walk in and buy things from the shelves.
- The back door is where a few trusted wholesalers bring in new stock or take surplus stock away.
- An ETF has two doors in just the same way.
- The front door is the exchange, where ordinary investors buy and sell existing shares from each other all day.
- That is the secondary market.
- The back door is the primary market, where only a small group of firms deal directly with the fund, to make new shares or cancel old ones.
- Those firms are called authorised participants.
- This first part of the lesson is all about the back door.

2 Creation and redemption

Creation

AP buys the basket → Delivers it to the fund → Receives a creation unit

Redemption

AP buys ETF shares → Returns a creation unit → Receives the basket

IN THE LESSON

- Here is the back door drawn as two rows.
- Follow the top row first, which is creation.
- An authorised participant, or AP, is a broker dealer with a contract with the fund's sponsor.
- It buys the basket of securities that the fund publishes each day.
- It delivers that basket to the fund, and pays a small creation fee.
- In return it receives a creation unit, which is a large block of new ETF shares, often fifty thousand of them.
- Now the bottom row, redemption, which is the same exchange run backwards.
- The AP buys ETF shares on the exchange, hands a full unit back, the shares are cancelled, and it receives the basket of securities, which it can then sell.

3 Why in kind matters

- Securities, not cash, move between AP and fund
- Fund need not sell holdings to meet outflows
- No trading costs for the investors who stay
- Helps tax efficiency; APs also arbitrage price gaps

IN THE LESSON

- Notice that securities pass between the AP and the fund, not cash.
- We call this an exchange in kind.
- It has two big benefits.
- First, when investors want out, the fund does not have to sell holdings to find cash.
- It simply hands over securities, so it pays no trading costs and those costs do not fall on the investors who stay.
- Second, handing over securities out of the fund can remove low cost-basis shares without a taxable sale, so the fund tends to be tax efficient, with fewer capital gains to pass on to holders.
- The AP has a second job too.
- It watches for gaps between the ETF price and the basket value, and trades to close them.
- That is arbitrage, and we will price it next.

4 The arbitrage profit

AP profit = (ETF price − basket value) × shares in unit − costs

ETF price	Where the ETF trades
Basket value	Per share value of the basket
Shares in a unit	Size of a creation unit
Fees and trading costs	Creation fee plus basket trading

IN THE LESSON

- When the ETF trades above the value of its basket, an AP can make money by creating shares.
- The profit equals the gap between the ETF price and the basket value per share, times the number of shares in a creation unit, minus the costs.
- The costs are the creation fee plus the trading costs of buying the basket.
- When the ETF trades below its basket, the signs flip.
- The AP buys the cheap shares, redeems them for the basket and sells the basket.
- Either way the AP earns the gap less the costs, provided the gap is big enough.
- If the gap is smaller than the costs, nothing happens, and the price is allowed to wander a little.

5 Example 1: a premium, so create

Basket 50.00 a share, unit 50,000 shares, ETF at 50.20

Buy the basket	50,000 × 50.00	**2,500,000**
Costs	500 + 0.05% × 2,500,000	**1,750**
Sell the new shares	50,000 × 50.20	**2,510,000**
AP profit	2,510,000 − 2,500,000 − 1,750	**8,250**

IN THE LESSON

- Here is a made up case.
- The Lantern Large Cap ETF has a basket worth fifty dollars a share.
- A creation unit is fifty thousand shares, so the basket costs two million, five hundred thousand dollars.
- The creation fee is five hundred dollars, and trading the basket costs point zero five per cent, which is one thousand, two hundred and fifty.
- Total costs are one thousand, seven hundred and fifty.
- Now the ETF trades at fifty dollars and twenty cents, a premium.
- The AP buys the basket, creates a unit, and sells the new shares for two million, five hundred and ten thousand.
- Subtract the basket and the costs, and the profit is eight thousand, two hundred and fifty dollars.
- The selling pushes the ETF price back down.

6 Example 2: a discount, so redeem

ETF at 49.80, basket 50.00, same unit and costs

Buy 50,000 ETF shares	50,000 × 49.80	**2,490,000**
Sell the basket received	50,000 × 50.00	**2,500,000**
Costs	500 + 1,250	**1,750**
AP profit	10,000 − 1,750	**8,250**

IN THE LESSON

- Now run the case the other way.
- Suppose the ETF drops to forty nine dollars and eighty cents, a discount to the basket of fifty.
- The AP buys fifty thousand ETF shares on the exchange for two million, four hundred and ninety thousand dollars.
- It redeems them and receives the basket, worth two million, five hundred thousand.
- Selling the basket brings that money in.
- The costs are the same one thousand, seven hundred and fifty.
- So the profit is ten thousand, minus one thousand, seven hundred and fifty, which is again eight thousand, two hundred and fifty.
- Notice what the buying did.
- It lifted the ETF price back towards the basket.
- So creation caps the premium, and redemption floors the discount.

7 How wide can the gap get?

- Redeem below 49.965
- Basket 50.00
- Create above 50.035

IN THE LESSON

- How big can a premium or discount get before the APs step in?
- Divide the costs by the shares in a unit.
- One thousand, seven hundred and fifty over fifty thousand is three and a half cents a share, which is point zero seven per cent of the basket.
- Here is the line.
- In the middle is the basket value, fifty dollars.
- To the right, a premium.
- Once the ETF is above fifty dollars and three and a half cents, creating pays, so APs create and sell, and the price is held down.
- To the left, a discount.
- Below forty nine dollars and ninety six and a half cents, redeeming pays, so APs buy and the price is held up.
- Inside the band, nothing is worth doing.

8 Trading at the front door

- Brokers, exchange, prices all day
- Market orders and limit orders; short selling; margin
- Investor to investor: share count unchanged
- Most volume never touches the underlying securities

IN THE LESSON

- Now the front door.
- Most ETF investors never meet the fund.
- They place an order with a broker, and it trades on an exchange against another investor, at a market price that moves all through the day.
- They can use market orders, which fill at once at the best available price, or limit orders, which only fill at the price they name or better.
- They can also sell short or buy on margin, just like a share.
- Here is the key point.
- When one investor sells to another, the number of ETF shares in existence does not change.
- Nothing happens inside the fund.
- Most ETF volume never touches the underlying securities.

9 Example 3: what changes the share count

Unit = 50,000 shares

Start of week	shares outstanding	**2,000,000**
AP creates 4 units	4 × 50,000	**+200,000**
Investors trade	600,000 shares	**no change**
AP redeems 3 units	3 × 50,000	**−150,000**
End of week	2,000,000 + 200,000 − 150,000	**2,050,000**

IN THE LESSON

- Let us track the shares of the Lantern fund over a week.
- It starts with two million shares outstanding.
- On Monday an AP creates four units, each of fifty thousand shares, so two hundred thousand new shares appear.
- On Tuesday investors trade six hundred thousand shares among themselves on the exchange.
- That is a big day of volume, yet the share count does not move at all.
- On Thursday an AP redeems three units, which cancels one hundred and fifty thousand shares.
- At the end of the week there are two million, fifty thousand shares outstanding.
- Only the back door changed the count.
- All the front door did was pass existing shares from hand to hand.

10 Two layers of liquidity

Small order

Investor sends order → Meets another investor → Share count unchanged

Large order

Market maker sells shares → Buys basket, AP creates → Share count rises

IN THE LESSON

- This leads to the idea of two layers of liquidity.
- The first layer is what you can see on the screen: the volume and the quotes in the ETF itself.
- The second layer is the liquidity of the securities the fund holds.
- Look at the top row, a small order.
- An investor sends it through a broker to the exchange and meets another investor.
- The screen is enough.
- Now the bottom row, a large order.
- A market maker, who quotes prices all day, sells the shares to the investor.
- To cover its position it buys the basket and has an AP create new shares to deliver.
- So a big order can be filled from the deep market in the holdings, not just from the thin market in the ETF.

11 Example 4: a big order, a thin screen

Made-up quote: 0.05% over the basket

Shares wanted	20,000,000 ÷ 50	**400,000**
Days of screen volume	400,000 ÷ 20,000	**20 days**
Creation units needed	400,000 ÷ 50,000	**8**
Cost of the trade	20,000,000 × 0.05%	**10,000**

IN THE LESSON

- A pension fund wants to buy twenty million dollars of the Lantern ETF at fifty dollars a share.
- That is four hundred thousand shares.
- The ETF trades only twenty thousand shares a day on screen, so the order is twenty days of volume.
- It looks impossible.
- But the fund holds large, easily traded stocks.
- A market maker quotes a price a little above the basket value, say point zero five per cent.
- It sells the four hundred thousand shares, buys the stocks, and an AP creates eight units to deliver.
- The cost is twenty million times point zero five per cent, which is ten thousand dollars.
- A day's screen volume was never the limit.
- The depth of the holdings was.

12 Mistakes to avoid so far

- Only APs create and redeem, in large units
- Investor-to-investor trades do not touch the fund
- Share count changes only through the back door
- Low ETF volume does not mean illiquid: check the basket

IN THE LESSON

- Here are the usual slips so far.
- First, thinking ordinary investors create or redeem shares.
- They do not.
- Only authorised participants do, in large units.
- Second, thinking an ETF must sell holdings whenever investors sell.
- When investors sell on the exchange, the fund does nothing at all.
- Third, thinking the exchange is where the fund gets new shares.
- It is not.
- New shares come from the back door.
- Fourth, and the favourite exam trap, thinking that a thinly traded ETF must be illiquid.
- If the holdings are liquid, a market maker can create or redeem units to meet a big order, so the real liquidity is that of the basket.
- Judge the holdings, not just the screen.

13 A fund that follows an index

- Tracking difference = fund return − index return
- Tracking error = standard deviation of those gaps
- Difference is the size of the shortfall
- Error is how much the gap wobbles

IN THE LESSON

- Most ETFs try to follow an index.
- So how closely do they succeed?
- Imagine a driver told to follow a lead car.
- The gap between the two cars can be measured in two ways.
- How far behind are you on average?
- And how much does the gap bounce around?
- These are two different questions.
- Tracking difference is the first: the fund's return minus the index's return over a period.
- It is the size of the shortfall.
- Tracking error is the second: the variability of that gap, usually the standard deviation of the period by period differences.
- A fund can be steadily behind, which is a large tracking difference with a tiny tracking error.
- Remember that, because it is the exam trap.

14 Tracking difference and error

d = Rfund − Rindex
TE = √[Σ(d − d̄)² ÷ (n − 1)]

Fund return	What the ETF returned
Index return	What the index returned
Gap in one period	Fund minus index, one period
Average gap	Average of the gaps

IN THE LESSON

- Here are the two measures in symbols.
- In each period, the gap is the fund's return minus the index's return.
- The tracking difference is the average of these gaps, or their total over a stretch of time.
- Tracking error is the sample standard deviation of the gaps.
- Take each gap, subtract the average gap, square it, add them up, divide by the number of periods minus one, and take the square root.
- If the gaps are quarterly and you want an annual figure, multiply by the square root of the number of quarters in a year, which is two.
- A constant gap has no spread around its average, so its tracking error is nothing at all.

15 Example 5: two funds, same shortfall

Quarterly gaps, fund minus index, in %

Fund A gaps	−0.05 every quarter	**average −0.05**
Fund A tracking error	the gap never varies	**0.00%**
Fund B gaps	+0.10 −0.25 +0.15 −0.20	**average −0.05**
Fund B squared deviations	sum of the four squares	**0.125**
Fund B tracking error	√(0.125 ÷ 3), a quarter	**0.204%**

IN THE LESSON

- Two ETFs follow the same index over four quarters.
- Fund A is behind the index by exactly point zero five per cent every quarter.
- The average gap is minus point zero five, and since the gap never varies, the tracking error is nil.
- Fund B's gaps are plus point one zero, minus point two five, plus point one five and minus point two zero.
- The average is also minus point zero five.
- The deviations from that average are point one five, minus point two zero, point two zero and minus point one five.
- Their squares add to point one two five.
- Divide by three and take the square root to get point two zero four per cent a quarter, or about point four one per cent a year.
- Same shortfall, very different reliability.

16 Where the shortfall comes from

Basis points a year

Expense ratio	**40**
Sampling	**10**
Cash drag	**5**
Index trading	**5**
Lending income	**−15**

Net shortfall: 40 + 10 + 5 + 5 − 15 = 45 bp

IN THE LESSON

- Now the sources.
- Here is a made up bar chart, in basis points a year, of what holds a fund behind its index.
- A basis point is one hundredth of one per cent.
- The tallest bar is the expense ratio, forty basis points, charged continuously out of the fund.
- Next is representative sampling, ten, which means holding only a sample of the index instead of every security, so returns drift away.
- Then cash drag, five, where dividends sit as cash before they are reinvested, and trading costs, five, paid when the index changes.
- The last bar works the other way: securities lending income, fifteen, which the fund earns by lending out holdings.
- Forty plus ten plus five plus five, minus fifteen, leaves a net shortfall of forty five.

17 Sources of tracking error, and their effect

Direction of each source

Source	Effect on the fund
Expenses, trading, cash drag	lag, mostly steady
Sampling, diversification limits	noise, wider error
Securities lending income	narrows the gap
International, futures funds	timing, roll costs

IN THE LESSON

- Let us sort the sources into a table.
- Fund expenses make returns lag the index, and they are close to constant, so they mostly show up as tracking difference.
- Representative sampling instead of full replication adds noise, so it widens tracking error.
- Transaction costs when the index changes, and cash drag from dividends waiting to be reinvested, both widen the gap.
- Securities lending income narrows it, because it offsets costs.
- Regulatory limits on how concentrated a fund can be force it away from the index weights.
- International funds add valuation timing and fair value pricing differences.
- Futures based funds add roll costs.
- Costs and cash drag are steady.
- The others vary from period to period.

18 The tracking trap

- Steady shortfall = tracking difference, not error
- Fee drag is nearly constant: little tracking error
- Sampling and timing effects create the noise
- Ask: size of the gap, or reliability of the gap?

IN THE LESSON

- Now the trap.
- A student sees a fund that is behind its index by the same small amount every period, and calls it a fund with a high tracking error.
- That is wrong.
- A steady shortfall is tracking difference.
- It is usually the expense ratio, and you can plan for it.
- Tracking error is about unpredictability.
- A cheap fund that samples the index may have a small average gap but a noisy one.
- An expensive fund that holds every security may have a bigger gap but a calm one.
- When you read a question, ask which of the two it wants.
- And if the question gives a constant fee drag, expect the tracking error to be close to nothing.

19 The price of a quick trade

- Bid: where you can sell now. Ask: where you can buy now
- Spread = what you pay for an instant trade
- It pays the market maker for cost and risk
- Like the rate gap at an airport booth

IN THE LESSON

- Last, the bid ask spread.
- The bid is the price at which you can sell right now.
- The ask is the price at which you can buy right now.
- The spread between them is what you pay for speed.
- Think of a currency booth at an airport.
- It buys at one rate and sells at a slightly higher one, and the difference pays for the risk and cost of holding currency until it can be passed on.
- An ETF market maker works the same way.
- When you buy, it sells you shares it may not own, and then has to cover.
- So the spread reflects the cost to the market maker of taking the other side and laying off the risk.

20 Building a spread from its parts

Spread ≈ fees + basket spread + risk and hedging + profit − offsets

Fees and trading	Creation fee and commissions
Spread on holdings	What the basket costs to trade
Risk and hedging	Holding risk and hedge cost
Profit less offsets	Profit less offsets

IN THE LESSON

- We can build the spread from its parts.
- The first part is the creation or redemption fee and other trading costs.
- The second is the spread on the underlying securities, because the market maker crosses that when it buys or sells the basket.
- The third is compensation for the risk that prices move while it holds the position, plus the cost of hedging that risk.
- The fourth is a normal profit, less any saving when buy and sell orders arrive together and cancel out.
- These are rough pieces, but the idea is sound: the ETF spread is bounded by what it costs to trade the basket and manage the risk.
- It is not set by the ETF's own volume.

21 Example 6: two funds, two spreads

Made-up components, in basis points

Fund L spread	1 + 2 + 1 + 1 + 1 − 1	**5 bp**
Fund J spread	3 + 10 + 12 + 5 + 2 − 2	**30 bp**
Fund L, 1,000,000 round trip	1,000,000 × 0.05%	**500**
Fund J, 1,000,000 round trip	1,000,000 × 0.30%	**3,000**

IN THE LESSON

- Compare two funds.
- Fund L holds United States large cap stocks and trades lightly.
- Its parts, in basis points, are fees one, basket spread two, risk one, hedging one, profit one, less one for offsetting orders.
- That adds to five basis points, point zero five per cent.
- Fund J holds Japanese stocks and is traded during New York hours, when Tokyo is shut.
- Its parts are fees three, basket spread ten, risk twelve, hedging five, profit two, less two.
- That adds to thirty basis points.
- On a round trip of one million dollars, the spread is paid once in all, so Fund L costs five hundred dollars and Fund J costs three thousand.
- The light trader is the cheap one.

22 Spreads follow the holdings

Spread (basis points)

Fund L	**5**
Fund J	**30**
Risk	**12**
Shares	**10**
Hedging	**5**
Fees	**3**
Profit	**2**

Fund J: fees 3 + shares 10 + risk 12 + hedge 5 + profit 2 − offsets 2 = 30

IN THE LESSON

- Here are the two spreads as bars, in basis points, with a bar for each part of Fund J.
- First the liquid fund, L, at five.
- The second bar is Fund J, at thirty.
- Then the pieces inside Fund J.
- The risk of holding a position while Tokyo is shut is twelve, the biggest piece, because the market maker cannot offset in the home market until it opens.
- The spread on the Japanese shares themselves is ten.
- Hedging adds five, and fees three.
- Profit is two.
- The saving from offsetting orders takes two off.
- The picture shows what drives the cost: the holdings and the hours of their market, not how busy the ETF itself happens to be.

23 What narrows or widens a spread

Drivers of the ETF bid-ask spread

Driver	Spread
Liquid large-cap holdings	narrower
Many competing market makers	narrower
Illiquid bonds, foreign shares	wider
Home market closed, high volatility	wider

IN THE LESSON

- Here is the summary.
- Narrow spreads go with funds holding liquid large cap stocks, which trade heavily, so the basket is cheap to trade.
- Many competing market makers also narrow the spread, because they bid the profit down.
- Easy creation and redemption, with low fees, narrows it as well.
- Wide spreads go with funds holding illiquid bonds, small stocks or foreign shares whose markets are closed, since the risk of holding the position is bigger and hedging is harder.
- High volatility widens spreads too, because the risk of an adverse move is larger.
- Few market makers leaves room for a fatter profit.
- In each case, ask what it costs to trade the basket and lay off the risk.

24 The spread trap

- Low ETF volume does not mean a wide spread
- Heavily traded bond ETF can still be wide
- Look first at the cost of trading the holdings
- Then hours, competition among market makers, fees

IN THE LESSON

- The trap in this outcome mirrors the earlier one.
- A student sees an ETF with low daily volume and says the spread must be wide.
- Not so.
- A fund of liquid stocks can have a very tight spread despite light trading, because the market maker can hedge at once and create or redeem cheaply.
- The reverse also holds.
- A heavily traded bond ETF can still have a wide spread, because the bonds it holds trade rarely and with wide dealer quotes.
- So the first place to look is the holdings.
- Then look at the hours of the home market, the number of market makers, and the costs of creating and redeeming shares.

25 Recap: the four ideas

Four outcomes in one table

Idea	Key point
Creation and redemption	APs swap baskets for units, in kind
Secondary market	share count unchanged; basket gives depth
Tracking	difference is size; error is wobble
Bid-ask spread	basket cost plus risk, not volume

IN THE LESSON

- Let us pull the lesson together.
- Authorised participants create and redeem shares in the primary market, swapping a basket of securities for a creation unit and back again, usually in kind.
- Their arbitrage keeps the ETF price within the costs of the basket.
- Ordinary investors trade existing shares on the exchange at market prices, and that does not change the share count, so the liquidity you can reach is that of the holdings as well as the screen.
- Tracking difference is the size of the gap to the index, driven mostly by costs.
- Tracking error is its variability, driven by sampling, timing and other noise.
- And the spread is the market maker's cost of trading the basket and managing the risk.

26 Quick check

1. Premium 0.10, unit 100,000, costs 1,000 + 0.04% of 3,000,000. AP profit?
   Answer: 10,000 − 2,200 = 7,800
2. Gaps −0.2%, −0.2%, −0.2%. Difference and error?
   Answer: Difference −0.2% a period; error 0.00%
3. Parts 2+8+6+3+2−1 bp. Round trip on 500,000?
   Answer: 20 bp, so 500,000 × 0.20% = 1,000

IN THE LESSON

- Question one.
- An ETF trades at thirty dollars and ten cents, and its basket is worth thirty.
- A unit is one hundred thousand shares, the fee is one thousand dollars, and trading the basket costs point zero four per cent.
- What is the AP's profit?
- The gap is ten thousand dollars.
- Costs are twenty two hundred, so profit is seven thousand, eight hundred dollars.
- Question two.
- A fund trails its index by point two per cent in each of three periods.
- What are its tracking difference and tracking error?
- The difference is minus point two per cent a period, and the error is nil, because the gap never varies.
- Question three.
- A spread has fees two, basket spread eight, risk six, hedging three, profit two, less one for offsetting orders, in basis points.
- What does a round trip on five hundred thousand dollars cost?
- The spread is twenty basis points, so it costs one thousand dollars, and that is the price of getting in and out.