CHARTA LEARNING · LESSON NOTES

Introduction to risk management

Portfolio Management

1 A story: the ship and the storm

- A ship cannot cross the ocean without weather
- The job: plan the route, keep a lookout
- Surprises are the danger: the unmarked reef
- Investors: take intended risks, avoid unintended ones

IN THE LESSON

- Picture the captain of a cargo ship.
- Nobody would say the captain's job is to avoid every storm.
- Ships exist to cross oceans, and oceans have weather.
- The job is to pick a route, carry enough fuel, keep a lookout, and know in advance what to do if the wind turns.
- The captain also does not want surprises, such as an unmarked reef or a leaking hull nobody told the bridge about.
- An investor is in the same position.
- Money is made by taking risks, so a plan that removes all risk also removes all return.
- What an investor needs is a way to take the intended risks and to stay clear of the others.

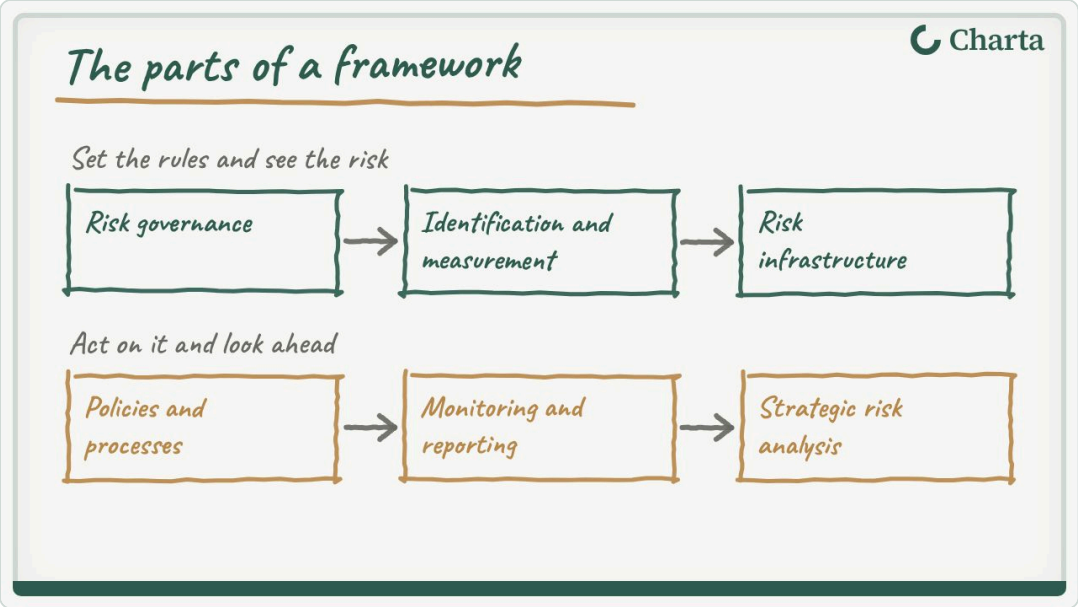
2 What a risk management framework is

- Framework = the system for handling risk on purpose
- Goal: intended risks, in intended amounts
- Goal is NOT the smallest possible risk
- No risk taken means no return earned

IN THE LESSON

- Now the proper name for that plan.
- A risk management framework is the whole system an organisation uses to make sure it takes the risks it meant to take, in the amounts it meant, and avoids the rest.
- Notice what it is not.
- Its goal is not to make risk as small as possible.
- A pension fund that put everything in cash would carry little risk, but it would also fail to earn what it needs to pay its members.
- So the framework is about choice.
- Which risks are we paid to take?
- How much of each can we bear?
- And how do we find out quickly when we have drifted away from the plan?
- To answer those questions properly, a framework has several parts.

3 The parts of a framework



IN THE LESSON

- Here are the parts, in the order a risk travels through them.
- Start at the top left.
- Risk governance comes first.
- Senior people decide how much risk the organisation will accept and who is accountable.
- Next, risk identification and measurement.
- You cannot manage what you have not spotted, so every exposure must be named and sized.
- Then risk infrastructure, which means the people, data and computer systems that do the measuring every day.
- Along the bottom row, policies and processes turn the tolerance into rules and limits.
- Monitoring and reporting compare what is actually held against those limits.
- And last, strategic risk analysis asks whether the risks we chose still make sense for the long term plan.

4 Risk governance: who is in charge

- Governance sets the tolerance at senior level
- It makes people accountable for limits
- Risk function must sit above the risk takers
- A referee paid by one team cannot be trusted

IN THE LESSON

- Let us look closer at the first box, because it holds the rest together.
- Risk governance is the top level structure of authority.
- It sets the risk tolerance, which is the amount of risk the organisation is willing and able to take.
- It assigns accountability, so that when a limit is broken a named person must answer for it.
- It also decides how risk information flows up to the board.
- The key design point is independence.
- The people who watch risk must not report to the people who take it.
- Think of a referee paid by one of the teams.
- The referee might be honest, but nobody would trust the whistle.
- Governance has to sit above the risk taking units.

5 Example 1: a breach at Maple Ridge

Equity desk limit set by the board: value at risk of 2.0 million

Limit approved in advance	set by governance	**2.0m**
Measured exposure	this morning's report	**2.6m**
Overshoot	2.6 − 2.0	**0.6m**
Utilisation of the limit	2.6 ÷ 2.0	**130%**

IN THE LESSON

- Let us follow a made up example.
- Maple Ridge is a pension fund.
- Its board has approved a limit for the equity desk, measured in value at risk, said V a R.
- Value at risk is an estimate of the loss that should not be exceeded on most days.
- The limit is two million.
- This morning the risk report shows that the desk's measured exposure is two point six million.
- The overshoot is two point six minus two, which is point six million.
- Utilisation, the exposure as a share of the limit, is two point six divided by two, or one hundred and thirty per cent.
- The numbers are invented for illustration.
- The question is: what has to work for this breach to be caught and acted on?

6 Example 1: how one weak link hides it

Each weak link lets the 0.6 million breach continue

Part that fails	Result
Identification	not counted
Measurement	understated
Infrastructure	a week late
Governance	cannot say no

IN THE LESSON

- Now walk down the framework and ask what happens if any single part fails.
- If identification fails, say a new instrument was never counted, the breach is simply not seen.
- If measurement fails, the exposure is understated, so the report shows two million when the truth is two point six.
- If infrastructure fails, data arrives a week late, and the breach has grown before anyone looks.
- And if governance fails, the report reaches a manager who reports to the very desk head whose bonus depends on the position, and who therefore cannot say no.
- Every link must hold.
- The last one is organisational rather than technical.

7 The part people forget: strategic risk analysis

- Other parts ask: are we inside the limits?
- Strategic analysis asks: are these the right risks?
- Example: a law change is not a position, so no limit
- Key point: infrastructure = people, data and systems

IN THE LESSON

- One part is easy to leave out, and it asks a different question from the others.
- The rest of the framework checks whether we are inside our limits.
- Strategic risk analysis asks whether the limits are about the right risks in the first place.
- A fund can sit inside every market risk limit and still be hurt by something that was never a position, such as a change in the law, or a sponsor company that stops paying contributions.
- Neither shows up in a limit report.
- So a good risk function also stands back and raises things nobody asked about.
- Remember the practical angle.
- The framework aims at intended risks, risk governance is independent of the risk takers, and infrastructure means people, data and systems.

8 A story: the holiday fund

- Question one: how much risk would you like?
- Question two: how much could you survive?
- A sensible plan obeys the smaller answer
- Risk tolerance combines both questions

IN THE LESSON

- Two friends each plan a holiday.
- The first says, I would be happy to lose some money on a risky bet, because I love a gamble.
- The second says, I could not afford to lose even a little, because the rent is due.
- Notice that these are two different questions.
- One is about appetite, how much risk you are comfortable with.
- The other is about ability, how much loss you could actually survive.
- A sensible plan listens to both and picks the smaller.
- Now put the friends inside an organisation.
- The board may feel brave, but if the fund has little spare money beyond what it owes, bravery is the wrong guide.
- Risk tolerance is built from exactly these two ideas.

9 Risk tolerance: willingness and capacity

- Willingness = how much loss the board accepts
- Capacity = how much loss the firm survives
- Tolerance = the LOWER of the two
- Set at senior level, then shared out

IN THE LESSON

- Let us name the two halves.
- Risk tolerance is the amount of risk an organisation is both willing and able to bear in pursuit of its goals.
- Willingness, sometimes called risk appetite, is how much loss the board is comfortable with.
- It is a matter of preference and attitude.
- Capacity, or ability, is how much loss the organisation can take and still meet its obligations and stay in business.
- It is a matter of facts, such as how much money exists above what is owed.
- The two can disagree.
- When they do, the lower one rules, because you cannot spend risk you cannot afford, however brave you feel.
- Risk tolerance is set at the senior level, and then it has to be shared out.

10 The formula for risk tolerance

Capacity = Assets − Minimum needed
Tolerance = lower of Willingness and Capacity

Assets held	What the organisation holds
Minimum needed	Needed to meet obligations
Risk capacity	The cushion that can be lost
Risk willingness	Loss the board accepts
Risk tolerance	The smaller of the two

IN THE LESSON

- Here is the idea as a short formula.
- First, capacity.
- It equals the assets held, minus the minimum amount the organisation needs to keep, such as the money required to meet its obligations or the capital a regulator demands.
- That gap is the cushion that could be lost without breaking the promise.
- Second, tolerance.
- It equals the lower of willingness and capacity.
- Willingness is the loss the board says it accepts.
- Capacity is the cushion.
- If the board accepts a smaller loss than the cushion, willingness rules.
- If the board is bolder than the cushion allows, capacity rules.
- Notice the trap: a board that is comfortable with a loss bigger than its capacity has ignored the facts.

11 Example 2: Maple Ridge sets its tolerance

Assets 500 million, minimum needed 410 million

Capacity	500 − 410	**90m**
Board A is willing to lose	case A	**60m**
Tolerance, case A	lower of 60 and 90	**60m**
Tolerance, case B	willing 120: lower of 120 and 90	**90m**

IN THE LESSON

- Example two.
- Maple Ridge holds assets of five hundred million.
- To meet its promises to members it needs at least four hundred and ten million to stay in the fund.
- So its capacity is five hundred minus four hundred and ten, which is ninety million.
- Now two boards.
- In case A the board says it is willing to accept a loss of up to sixty million.
- Sixty is below ninety, so the tolerance is sixty million.
- In case B a bolder board says it is willing to lose one hundred and twenty million.
- That is above the cushion of ninety, so capacity rules and the tolerance is only ninety million.
- A loss of one hundred and twenty would leave the fund below what it owes.
- These figures are invented.

12 Risk budgeting: sharing out the total

- Budget = total tolerance split across activities
- Set BEFORE the exposures are taken
- Units: standard deviation, VaR, or contribution
- Contribution is the most informative

IN THE LESSON

- The tolerance is one number for the whole organisation.
- But risk is taken by many hands, such as an equity team, a bond team and a team in alternatives.
- Risk budgeting is the step that allocates the total tolerance across specific activities, much as a household budget splits monthly income across rent, food and travel.
- The crucial feature is timing.
- The budget is set before the exposures are taken.
- That means the limit is agreed when nobody has a stake in a position.
- If the limit is argued about afterwards, the trader who wants to keep the position will argue for more room.
- A budget can be written in standard deviation, in value at risk, or in contribution to total risk.

13 Contribution to total risk

Contribution = w × Cov(position, portfolio) ÷ σp
Sum of contributions = σp

Weight	Share of money in the position
Covariance with portfolio	Weighted sum of its covariances
Portfolio risk	Standard deviation of portfolio
Contribution to risk	What it adds to portfolio risk

IN THE LESSON

- Why is contribution the most informative?
- Because positions interact.
- A position's standalone risk ignores that.
- Contribution asks how much the position adds to the risk of the whole portfolio.
- Here is the formula.
- Contribution equals the weight of the position, times its covariance with the portfolio, divided by the risk of the portfolio.
- Covariance with the portfolio is the weighted sum of its covariances with every holding, itself included.
- The beautiful property is that the contributions of all the positions add up to the portfolio's standard deviation.
- Divide each by the total and you get shares that add to one hundred per cent.
- A position that moves with everything else contributes a lot.
- One that moves differently contributes little.

14 Example 3: three desks (set-up)

Weights 50 / 40 / 10, correlations E–B 0.2, E–A 0.5, B–A 0.1

Equities	risk 18%	**50%**
Bonds	risk 6%	**40%**
Alternatives	risk 12%	**10%**
Covariance E–B	0.2 × 0.18 × 0.06	**0.00216**

IN THE LESSON

- Example three.
- Maple Ridge holds three things.
- Fifty per cent of its money is in equities, with a standard deviation of eighteen per cent.
- Forty per cent is in bonds, with a standard deviation of six per cent.
- Ten per cent is in alternatives, with a standard deviation of twelve per cent.
- The correlations are zero point two between equities and bonds, zero point five between equities and alternatives, and zero point one between bonds and alternatives.
- Covariance is correlation times the two risks.
- So equities with bonds is zero point two times point one eight times point zero six, which is point zero zero two one six.
- Equities with alternatives is point zero one zero eight.
- Bonds with alternatives is point zero zero zero seven two.
- The variance of each asset on its own is its risk squared.

15 Example 3, step 1: portfolio risk

Variance = sum of weight × covariance with portfolio

Equities with portfolio	0.5×0.0324 + 0.4×0.00216 + …	**0.01814**
Bonds with portfolio	same method	**0.00259**
Alternatives with portfolio	same method	**0.00713**
Portfolio variance	weights × these three	**0.01082**
Portfolio risk	square root	**10.40%**

IN THE LESSON

- Step one is the portfolio risk.
- For each asset, work out its covariance with the portfolio: the weights times that asset's covariances with every asset, itself included.
- For equities that is point five times point zero three two four, plus point four times point zero zero two one six, plus point one times point zero one zero eight.
- That comes to point zero one eight one four.
- In the same way bonds give point zero zero two five nine and alternatives give point zero zero seven one three.
- The portfolio variance is the weights times these three, which is point zero one zero eight two.
- The square root is ten point four per cent.
- Compare that with the weighted average of the standalone risks, twelve point six per cent.
- Diversification has helped.

16 Example 3, step 2: contribution to risk

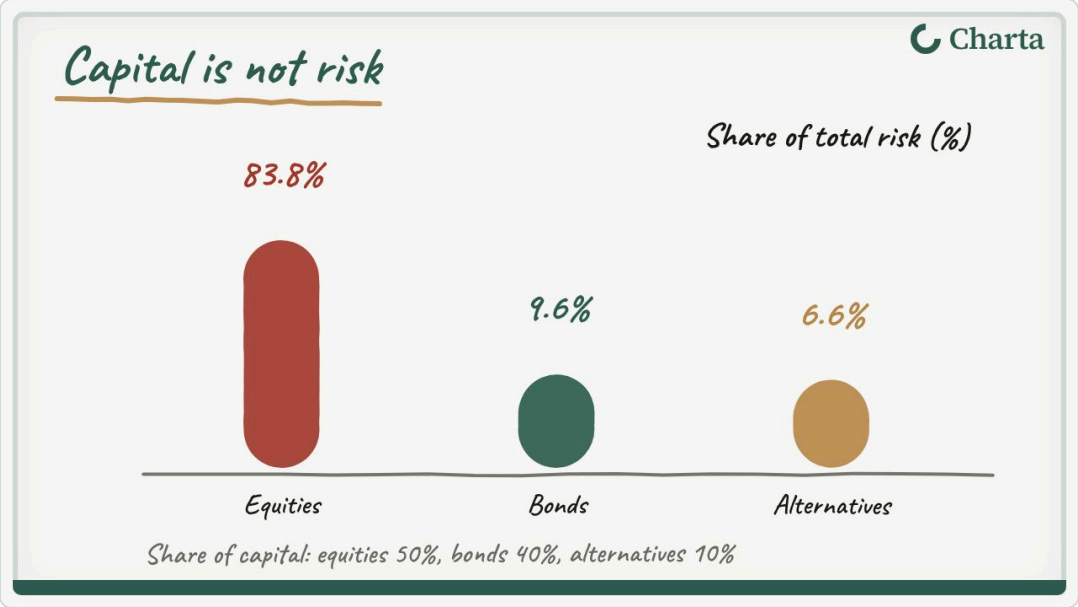
Contribution = w × Cov with portfolio ÷ 0.1040

Equities	0.5 × 0.01814 ÷ 0.1040	**8.7 points**
Bonds	0.4 × 0.00259 ÷ 0.1040	**1.0 points**
Alternatives	0.1 × 0.00713 ÷ 0.1040	**0.7 points**
Total	8.7 + 1.0 + 0.7	**10.4%**

IN THE LESSON

- Step two.
- Contribution equals weight times covariance with the portfolio, divided by the portfolio risk of point one zero four.
- Equities: point five times point zero one eight one four, divided by point one zero four, is point zero eight seven, or eight point seven points of risk.
- Bonds: point four times point zero zero two five nine, over point one zero four, is about one point.
- Alternatives: point one times point zero zero seven one three, over point one zero four, is about point seven.
- Add them: eight point seven, plus one, plus point seven, is ten point four, exactly the portfolio risk.
- As shares, equities are eighty three point eight per cent, bonds nine point six, and alternatives six point six.

17 Capital is not risk



IN THE LESSON

- Here are those shares as a picture.
- The vertical axis is the share of total risk, in per cent.
- The first bar, in red, is equities.
- They hold only fifty per cent of the capital, yet they produce eighty three point eight per cent of the total risk, because they are the most volatile and they move with the alternatives too.
- The second bar, in green, is bonds.
- Forty per cent of the capital, but only nine point six per cent of the risk.
- The third bar is alternatives, ten per cent of the capital and six point six per cent of the risk.
- If the board budgeted by capital, it would think equities were half the story.
- By risk contribution, they are nearly all of it.

18 Example 4: two desks, one bet

Two desks, each with risk of 4 million. Combined risk?

If unrelated, ρ = 0	√(16 + 16)	**5.66m**
Same exposure, ρ = 0.9	√(16 + 16 + 2×0.9×16)	**7.80m**
Perfectly together, ρ = 1	4 + 4	**8.00m**

IN THE LESSON

- Example four shows why limits must allow for correlation.
- Two desks each hold a position with a standard deviation of four million.
- Each sits inside its own limit.
- If the two positions were unrelated, the combined risk would be the square root of sixteen plus sixteen, which is five point six six million.
- If they moved perfectly together, risk would simply add to eight million.
- Now suppose both desks hold the same underlying exposure, so the correlation is zero point nine.
- The variance is sixteen plus sixteen plus two times zero point nine times four times four, which is sixty point eight.
- The square root is seven point eight million.
- Each desk looked modest alone.
- Together they are almost the same bet twice.

19 Four mistakes to avoid so far

- 1. Aiming for the smallest risk, not the intended risk
- 2. Risk function reporting to the people it checks
- 3. Tolerance from willingness alone: capacity rules too
- 4. Budgeting by capital or standalone risk, not contribution

IN THE LESSON

- Time to collect the traps from the first two outcomes.
- One.
- Treating the aim as the smallest possible risk.
- The aim is to take intended risks in intended amounts.
- Two.
- Letting the risk function report to the risk takers.
- Governance must sit above them, otherwise the whistle cannot be trusted.
- Three.
- Setting tolerance from willingness alone.
- Capacity matters, and the lower of the two governs.
- Four.
- Budgeting by capital or by standalone volatility.
- Those ignore correlation.
- Contribution to total risk shows where the risk really sits, and its parts add up to the whole.
- If a question mentions two desks with the same exposure, think correlation.

20 A story: the family home

- Do not buy on the flood plain: avoid
- Buy and keep savings to repair: retain
- Buy flood insurance: transfer
- Build barriers to reshape the damage: shift

IN THE LESSON

- Think about a family and its house.
- A flood is possible, and the family has four options.
- They could decide not to buy a house on the flood plain at all.
- That is avoiding the risk.
- They could buy the house and put aside savings to repair the damage, keeping the risk and holding money against it.
- That is retaining the risk.
- They could buy flood insurance, so that an insurer pays if the water comes.
- That is transferring the risk.
- Or they could raise the floor and fit flood barriers, so that the house still stands in the flood zone but the damage in a flood is smaller.
- That reshapes the outcome.
- In finance, that last idea is called shifting.

21 The four responses to a risk

- Avoid: do not do the activity at all
- Retain: keep it, with capital held against it
- Transfer: pass it to another party, such as an insurer
- Shift: use derivatives to reshape the payoff

IN THE LESSON

- Here are the four responses, in finance language.
- Avoidance means not undertaking the activity at all, so no exposure is left.
- Retention means taking the risk on and holding capital against it, knowingly.
- Transfer means passing the risk to another party, for a fee, as with insurance.
- Shifting means using derivatives, which are contracts whose value depends on another asset, to change the shape of the payoff, for example cutting off the worst outcomes while keeping the good ones.
- Transfer and shifting are easy to confuse.
- Insurance moves the risk to someone else's balance sheet.
- A derivative leaves the position with you but changes its payoff, and it can bring a risk of its own, that the other side fails to pay.

22 How to choose a response

- Paid to bear it, with an advantage? Retain it
- Unrewarded or outside our skill? Avoid, transfer, shift
- Every hedge has a cost: buy it only if worth it
- Never hedge away the risk that is the business

IN THE LESSON

- Which of the four is right?
- The answer turns on two things.
- The first is whether the organisation is paid to bear the risk and has an advantage in bearing it, meaning better skill, better information or better diversification than others.
- If yes, keep it.
- A bank skilled at credit analysis keeps loan risk, because that is its business.
- The second is cost.
- Hedging a risk costs money, so it is worth buying only if the risk is not rewarded and the cost is lower than the pain.
- Risks the organisation is not paid for, or which lie outside its skill, are better avoided, transferred or shifted.
- An insurer that hedged away all its underwriting risk would have given up the very risk it is paid to bear.

23 Example 5: one trade, three risks (set-up)

100 million of foreign bonds brings three risks

Credit risk, paid about	extra yield 1.2%	**1.2m**
Currency risk, one swing	9% of 100m	**9.0m**
Operational risk	custody failure	**no reward**

IN THE LESSON

- Example five.
- Maple Ridge buys a one hundred million portfolio of bonds issued by foreign companies, priced in a foreign currency.
- Three risks arrive together.
- First, credit risk, the chance a company fails to pay.
- The bonds offer extra yield for this, worth about one point two million a year, so Maple Ridge is paid to bear it and has analysts for the job.
- Second, currency risk.
- The foreign currency has a standard deviation of nine per cent a year, but it carries no expected extra reward.
- That is nine million of swing.
- Third, operational risk, such as a custody failure, where a bank holding the bonds loses them.
- There is no reward at all for that.
- These numbers are invented.

24 Example 5, step 2: a response for each

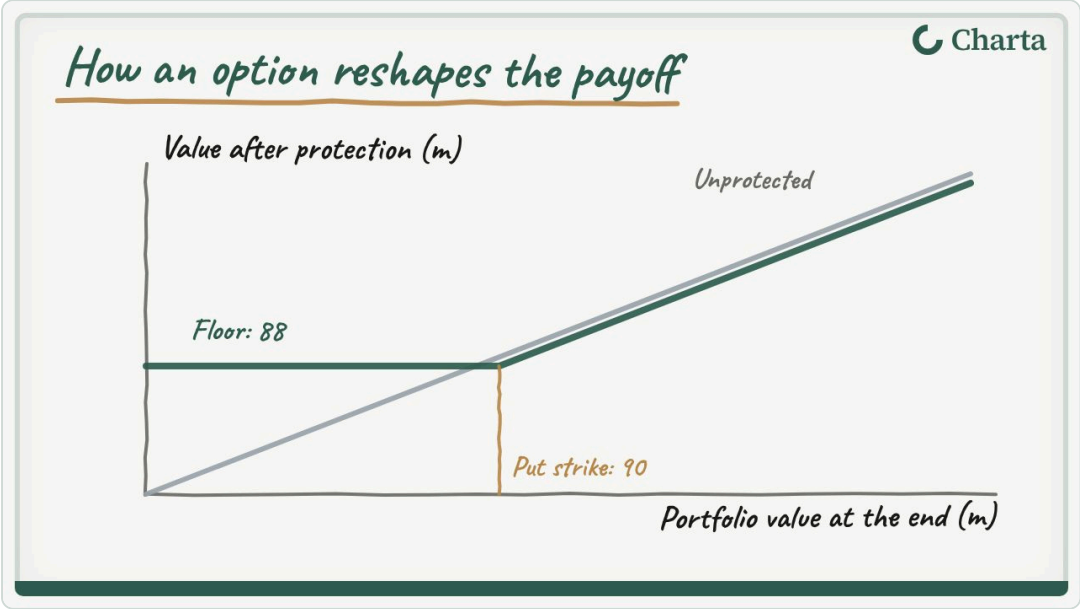
Retain what you are paid for; hedge or pass on the rest

Credit risk	paid and skilled	**retain**
Currency risk	forward costs 0.4m	**shift**
Operational risk	insurance, custodian	**transfer**
Left over	the intended risk	**credit**

IN THE LESSON

- Step two, match each risk to a response.
- Credit risk is the reason for the trade, and Maple Ridge has the skill, so it retains it and holds capital against it.
- Currency risk pays nothing, and a nine million swing is large next to the reward.
- A forward contract, a deal to exchange currency at a fixed rate, can lock the exchange rate.
- Suppose the cost of the hedge is zero point four per cent, which is point four million.
- That is a lot less than the nine million swing it removes, so the fund shifts the risk.
- Operational risk is handled by transferring it, partly with insurance and a reliable custodian.
- What is left is the risk the manager meant to take.
- That is the aim of the framework.

25 How an option reshapes the payoff



IN THE LESSON

- Shifting is easiest to see in a picture.
- Start with a portfolio worth one hundred million, and buy a protective put option.
- A put gives the right to sell at a set price, here ninety million, and it costs two million.
- The horizontal axis is what the portfolio is worth at the end of the year, in millions.
- The vertical axis is what you are left with after protection, in millions.
- The grey line is the unprotected portfolio, a straight diagonal.
- The green line is the protected one.
- Below ninety it is flat at eighty eight: ninety from the put, less the two million cost.
- Above ninety it rises with the market, but two million lower.
- The losses are cut off while the gains stay open.

26 Example 6: the put in numbers

Portfolio 100m, put strike 90m, premium 2m

Ends at 70	sell at 90, less 2	**88m**
Ends at 90	90 − 2	**88m**
Ends at 100	100 − 2	**98m**
Ends at 120	120 − 2	**118m**

IN THE LESSON

- Example six puts numbers on the picture.
- The portfolio is worth one hundred million, the put has a strike of ninety, and the premium is two million.
- Suppose the portfolio ends the year at seventy.
- Unprotected, that is a thirty million loss.
- With the put, you sell at ninety, so you hold ninety less the two million premium, which is eighty eight.
- At ninety the answer is also eighty eight.
- At one hundred, the put is worthless and you hold one hundred less two, ninety eight.
- At one hundred and twenty, one hundred and eighteen.
- So the worst you can end with is eighty eight, a loss of twelve, and you keep the upside minus two.
- That is shifting: the shape of the outcomes has changed.

27 Changing exposure with futures

Futures = (β wanted − β now) ÷ β futures × Value
Negative means sell, positive means buy

Beta wanted	Exposure you want to end with
Beta now	Exposure you have today
Beta of futures	Futures usually track the market
Portfolio value	Money in the portfolio
Futures to sell	Notional amount to trade

IN THE LESSON

- Options are one tool.
- A second way to change exposure is to trade futures, contracts that let you gain or lose with a market without selling the holdings.
- Suppose a portfolio behaves like the market with a beta of one, and you want a beta of only point six.
- Beta measures how strongly the portfolio moves with the market.
- The notional amount of futures to trade is the beta you want, minus the beta you have, divided by the beta of the futures, times the value of the portfolio.
- A negative answer means sell futures.
- Here the answer is point six minus one, over one, times the value.
- This is a quick, cheap way to dial the exposure up or down, without selling the underlying holdings.

28 Example 7: cutting exposure by selling futures

Equities 200m, beta 1.0, target beta 0.6, futures beta 1.0

Futures notional	(0.6 − 1.0) ÷ 1.0 × 200	**sell 80m**
Market falls 10%: shares	−10% × 200	**−20m**
Market falls 10%: futures	+10% × 80	**+8m**
Net loss	−20 + 8	**−12m**

IN THE LESSON

- Example seven.
- Maple Ridge has a two hundred million equity portfolio with a beta of one.
- The board wants a beta of point six for a few months, without selling shares.
- The futures have a beta of one.
- The notional is point six minus one, divided by one, times two hundred million.
- That is minus point four times two hundred, minus eighty million.
- So sell eighty million of futures.
- Test it.
- Suppose the market falls ten per cent.
- The shares lose twenty million.
- The futures gain ten per cent of eighty, eight million.
- The net loss is twelve million, which is point six times the market fall of ten per cent, times two hundred.
- The exposure has changed exactly as intended.

29 Recap: the formulas to remember

Capacity = Assets − Minimum
Contribution = w × Cov ÷ σp
Futures = (β wanted − β now) ÷ β fut × Value

Risk capacity	Tolerance = lower of will, cap
Contribution to risk	Parts add up to σp
Futures to sell	Negative means sell futures
Four responses	Avoid, retain, transfer, shift

IN THE LESSON

- Let us pull it together.
- Risk management is about intended risks in intended amounts, with governance independent of the risk takers.
- Risk tolerance is the lower of willingness and capacity, and capacity is assets minus the minimum needed.
- A risk budget shares the tolerance across activities before exposures are taken, and the best measure is contribution to total risk, weight times covariance with the portfolio over portfolio risk, with parts that add up to the whole.
- Then four responses: avoid, retain, transfer, shift.
- Keep the risks you are paid for, and change the rest.
- To change exposure with futures, trade the difference in beta times value, over the futures beta.

30 Try three quick questions

1. Which framework part sets tolerance? Independent of whom?
   Answer: Risk governance; independent of the risk takers
2. Assets 300m, minimum needed 255m, board willing to lose 60m. Tolerance?
   Answer: Capacity 45m is lower than 60m: 45m
3. 50m portfolio, beta 1.0, want 0.5, futures beta 1.0. Trade?
   Answer: (0.5 − 1.0) × 50 = −25: sell 25m

IN THE LESSON

- Now try three questions yourself.
- Pause after each one.
- Question one.
- Which part of a framework sets the risk tolerance and makes people accountable, and who must it be independent of?
- The answer is risk governance, and it must be independent of the risk takers.
- Question two.
- Assets are three hundred million, the minimum needed is two hundred and fifty five million, and the board is willing to lose sixty million.
- What is the tolerance?
- Capacity is forty five, which is below sixty, so the tolerance is forty five million.
- Question three.
- A fifty million portfolio has a beta of one, and you want point five using futures with a beta of one.
- What do you trade?
- You sell twenty five million of futures.