CHARTA LEARNING · LESSON NOTES

The governance of risk management

FRM Part I

1 A story: the trader, the boss and the bonus

- Bonus on revenue: gains are shared, losses are not
- The risk manager reports to the business he monitors
- Directors cannot challenge what they do not understand
- Governance = oversight, responsibility, accountability

IN THE LESSON

- Picture a trading desk at a large bank in the years before the crisis.
- The head trader is paid a bonus based on the revenue the desk earns this year.
- If a bet works, the bonus is huge.
- If it fails, the loss falls on the bank, and the shareholders, and sometimes the public.
- The risk manager who could say stop sits two levels below, reports to the head of the business, and has no direct line to the board.
- The directors who oversee the bank are not sure how the trading book even works.
- Nobody is acting illegally, yet the setup invites trouble.
- Governance means the structure of oversight, responsibility and accountability that keeps this from happening.

2 What the crisis exposed inside firms

- Risk functions were siloed, not seen firm-wide
- Chief risk officers lacked seniority and independence
- Boards had little risk expertise
- Pay rewarded short-term revenue with no charge for risk

IN THE LESSON

- The course makes a strong point: the two thousand seven to two thousand nine crisis exposed governance failures as much as model failures.
- Risk functions were siloed.
- Market risk, credit risk and liquidity risk were watched by separate teams, and nobody added them up across the firm.
- Chief risk officers often lacked seniority and independence, so a risk officer could be overruled by a revenue producing executive.
- Boards had little risk expertise, so they could not tell whether the figures they were shown made sense.
- And pay rewarded short term revenue with no charge for the risk taken to earn it.
- Each of these is a weakness you should be able to name, because most of them later drew a specific fix, as we will see.

3 Measurement weaknesses: calm-period VaR and liquidity

- VaR calibrated to calm periods understated tail losses
- Liquidity risk was ignored or underestimated
- Models assumed positions could always be sold
- Weakness showed up exactly when markets froze

IN THE LESSON

- The crisis also showed a measurement weakness.
- Value at risk, or V a R, is an estimate of how much a portfolio could lose over a short period at a chosen confidence level.
- Many firms calibrated it to a recent calm stretch, when markets barely moved.
- A model fed calm data produces small numbers, so the tail losses that arrived in the crisis were understated.
- Liquidity risk made things worse.
- Liquidity risk is the danger that you cannot sell an asset or raise cash quickly without a heavy loss, or cannot fund yourself at all.
- Models often assumed positions could be sold at normal prices whenever needed.
- In the crisis, markets froze, and that assumption failed exactly when it mattered.

4 Each reform answers a specific weakness

Siloed risk and weak CROs were met by best practice (next slides)

Weakness	Reform
Weak board oversight of risk	Board risk committees
Thin capital, liquidity strain	Basel III rules
Too big to fail, own trading	Living wills, FSOC, Volcker
Short-term pay, calm VaR	Deferred pay, stressed VaR

IN THE LESSON

- A pattern is worth remembering: each reform answers a specific crisis weakness, so it helps to be able to match them.
- Let me give you the matching table.
- Weak board oversight was answered by board risk committees.
- Siloed risk functions and weak chief risk officers were not fixed by one named rule; they were met by the best practice we study shortly.
- Thin capital, in both quality and quantity, was answered by Basel three capital rules and a leverage ratio.
- Liquidity strain was answered by the liquidity coverage ratio and the net stable funding ratio.
- Banks that were too big to fail were answered by resolution plans, called living wills, and by the Financial Stability Oversight Council, and risky trading with the firm's own money by the Volcker Rule.
- Pay for short term revenue was answered by deferred, risk adjusted pay, and calm period V a R by stressed V a R.

5 Dodd-Frank: the United States response

- Passed 2010 in the United States
- FSOC watches system-wide risk
- Volcker Rule limits proprietary trading
- Stress tests, living wills and board risk committees

IN THE LESSON

- In the United States the main response was the Dodd-Frank Act, passed in twenty ten.
- It did several things worth knowing.
- It created the Financial Stability Oversight Council, a body of regulators that watches for risks to the whole financial system rather than to one firm.
- It added the Volcker Rule, which limits banks from proprietary trading, meaning trading with the firm's own money for its own profit.
- It required stress tests, which ask how a firm would fare in a severe scenario.
- It required large firms to file resolution plans, nicknamed living wills, which explain how the firm could be wound down in an orderly way without taxpayer rescue.
- And it required board risk committees.

6 Basel III: stronger capital and liquidity

- Higher quality and quantity of capital
- Leverage ratio: a simple, model-free backstop
- Liquidity coverage: liquid assets for a stressed month
- Net stable funding ratio: stable funding over a year
- Agreed 2010, phased in over the following years

IN THE LESSON

- The international response came from the Basel Committee, which writes standards that national supervisors apply.
- Basel three was agreed in twenty ten and phased in over the following years.
- It did four things.
- It raised the quality of capital, meaning more of it must be able to absorb losses while the bank is still running, such as common equity.
- It raised the quantity of capital that must be held.
- It added a leverage ratio, a simple limit on how large total exposures, including those off the balance sheet, can be compared with capital, which does not depend on risk weights or models.
- And it added two liquidity standards.
- The liquidity coverage ratio asks whether the firm holds enough high quality liquid assets for a stressed month.
- The net stable funding ratio asks whether its funding is stable over a year.

7 Pay and stressed VaR: the supervisory push

- Deferred pay: part of the bonus is paid years later
- Risk-adjusted pay: the bonus reflects the risk taken
- Stressed VaR, added to ordinary VaR, uses a stress period
- Each fix answers a named crisis weakness

IN THE LESSON

- Supervisors also went after the incentives and the models.
- On pay, they pushed for compensation that is deferred, so part of the bonus is paid years later, and risk adjusted, so that the amount reflects the risk taken and not only the revenue earned.
- If losses appear later, the deferred part can shrink.
- On models, regulators added stressed V a R, in the two thousand nine market risk revisions sometimes called Basel two and a half.
- Capital for trading risk now counts stressed V a R as well as ordinary V a R.
- Ordinary V a R uses recent history, which may be calm.
- Stressed V a R uses data from a period of serious market stress, about a year, so capital held against trading risk does not fall just because markets have been quiet.
- These measures fit the pattern again.
- The weakness was pay without a charge for risk and models blind to bad times, and the fixes answer exactly that.

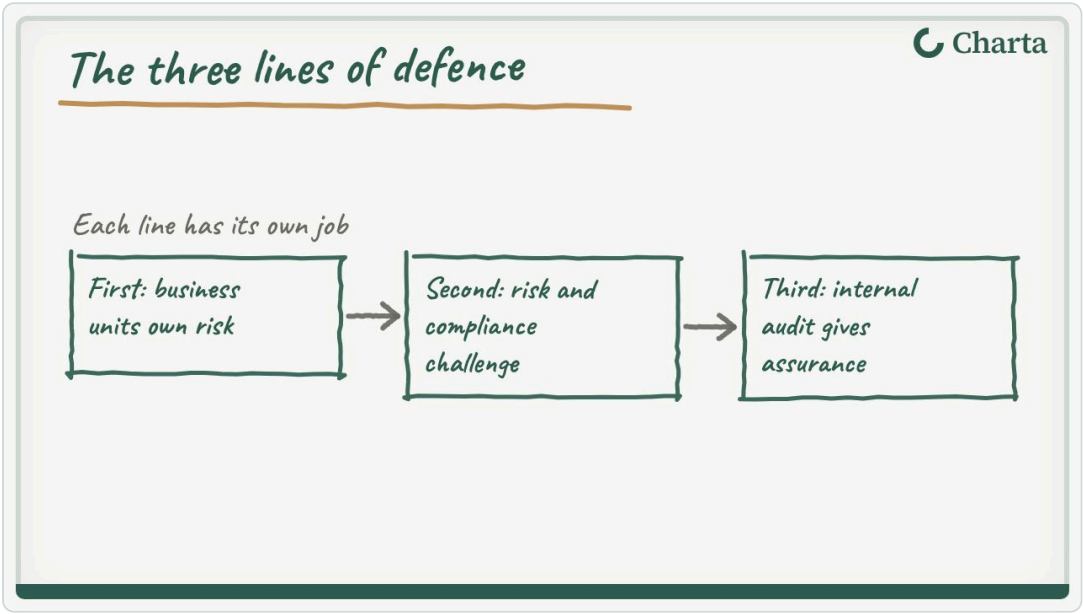
8 What good risk governance rests on

- Board approves appetite, oversees via committee
- Senior CRO leads the independent risk function
- Three lines of defence divide the responsibility
- Limits, validation, reporting, pay, risk culture

IN THE LESSON

- Now the second question: what does good governance look like?
- Risk governance is the structure of oversight, responsibility and accountability around risk taking, and it rests on a few repeatable practices.
- The board approves a risk appetite statement, which says how much and what kind of risk the firm will accept, and oversees it through a risk committee.
- A chief risk officer of senior standing leads the independent risk function.
- Responsibility is divided among three lines of defence.
- Limits, escalation, independent validation, enterprise wide reporting and aligned pay complete the picture.
- All of this is held together by risk culture, the shared attitude toward risk, which is set by tone at the top.
- Arrangements vary by firm, code and jurisdiction.

9 The three lines of defence



IN THE LESSON

- Here are the three lines of defence.
- Read the boxes from left to right.
- The first line is the business units.
- They take the risks to earn revenue, so they own and manage those risks day to day.
- The second line is independent risk management and compliance.
- They set the framework, measure risk, and oversee and challenge the first line.
- The third line is internal audit, which gives independent assurance to the board that the first two lines work as designed.
- The key idea is ownership.
- Risk is not the risk department's problem.
- The people earning the revenue own the risk, the second line challenges them, and the third line checks both.
- If the lines are merged, the challenge is no longer independent.

10 The chief risk officer

- Senior standing in executive decisions
- Independent of revenue-producing units
- Reports to the CEO
- Direct access to the board or its risk committee

IN THE LESSON

- The chief risk officer, or C R O, is the senior executive who leads the independent risk function.
- Good practice commonly calls for four features.
- First, senior standing, so the C R O has weight in executive decisions and can say no to powerful revenue producers.
- Second, independence from revenue producing units: the C R O should not be paid by, promoted by, or reporting to the businesses being monitored.
- Third, a reporting line to the chief executive officer.
- Fourth, direct access to the board or its risk committee, so concerns can reach directors without being filtered.
- Notice that the board should also care about the officer's independence.
- Again, exact arrangements vary by firm, governance code and jurisdiction, so learn the principle.

11 Good practice against the usual trap

Reporting, budget, board access and bonuses: good against trap

Good practice	The trap
Reports to CEO and board	The desk head
Independent budget	Paid by the desk
Direct board access	Filtered
Pay not tied to revenue	Tied to revenue

IN THE LESSON

- Let me put good practice beside the usual trap.
- The trap is a risk function that reports to, or is paid from, the units it monitors.
- Look at the table.
- If the head of risk reports to the head of trading, the person being checked decides the career of the checker.
- If the risk team is paid from the desk's budget, the desk can starve it.
- If the chief risk officer has no board access, bad news can be softened on the way up.
- If bonuses for risk staff depend on desk revenue, the incentive is to approve risk.
- In each case the good version is the mirror image: independence in reporting, in pay, and in access.

12 The working tools of risk governance

- Limits cap risk, with escalation of every breach
- Independent model validation
- Independent price verification of positions
- Enterprise-wide reporting and pay aligned with risk

IN THE LESSON

- Beyond structure, firms use a few working tools, and you should be able to list them.
- Limits cap the risk a unit may take, such as a maximum value at risk for a desk.
- Escalation means that a breach of a limit is reported upward on a set path, and not quietly fixed or ignored.
- Independent model validation means models are checked by people who did not build them.
- Independent price verification means that positions are valued by a unit separate from the traders who hold them.
- Enterprise wide reporting brings every risk together in one picture for senior management and the board.
- And pay aligned with risk ties rewards to the risk taken.
- Without these, the structure exists only on paper.

13 Case 1: a limit breach and its escalation

Illustration: a desk with a VaR limit of $20m

Limit	set by management, in appetite	**$20m**
Usage reported	independent risk system	**$26m**
Breach	26 − 20	**$6m**
Breach as share of limit	6 ÷ 20	**30%**
Who decides	CRO, not the desk head	**Escalate**

IN THE LESSON

- Let us work a case.
- A trading desk has a value at risk limit of twenty million dollars.
- On Tuesday the risk system reports usage of twenty six million.
- The breach is six million, and as a share of the limit, six over twenty, that is thirty per cent over.
- What should happen under good governance?
- The breach is not fixed quietly by the desk head.
- It is reported to the independent risk function, and escalated to the chief risk officer, who decides whether to cut the position, grant a temporary, documented exception, or raise the issue with the risk committee.
- The point is the path, not the number.
- The breach must be visible, someone independent must decide, and the outcome must be recorded.
- The figures here are an illustration only.

14 The board: oversees risk, does not run it

- Approves strategy and risk appetite
- Ensures a capable framework, resources and systems
- Oversees compensation so pay fits the appetite
- Oversees CRO independence, appointment, removal

IN THE LESSON

- Now the board of directors.
- The rule to carry in your head is this: the board oversees risk and does not run it.
- The board is appointed on behalf of the owners, usually elected by shareholders, to govern the firm.
- It approves the strategy and the risk appetite.
- It makes sure management has a capable framework, resources and systems to stay within that appetite.
- And it oversees compensation so that pay does not reward risk beyond the appetite.
- Good practice commonly includes board oversight of the chief risk officer's independence, with an appropriate board part in that person's appointment, evaluation and, if necessary, removal.
- Arrangements vary by firm, governance code and jurisdiction.
- The board sets the direction and checks the work.
- Management does the work.

15 The risk committee and the duty to challenge

- Risk committee: independent directors with risk expertise
- Delegating detail does not remove accountability
- Directors challenge, and ask for independent assessments
- They review reports on limits, stress tests and breaches

IN THE LESSON

- Most boards delegate the detailed work to a risk committee.
- This is a committee of the board, made up of independent directors, meaning directors who are not part of management, and ideally with real risk expertise.
- Delegation does not remove responsibility, though.
- The full board stays accountable for risk oversight.
- What should directors actually do?
- They must challenge management rather than accept presentations at face value.
- They should ask for independent assessments, for example from the risk function or from internal audit, not only from the executives who run the business.
- And they should review reports on limits, stress tests and breaches, so they see where the firm is close to its edge and how often it goes over.

16 Board duty against management duty

Oversight belongs to the board, running the business to management

Task	Who owns it
Approve risk appetite	Board
Approve strategy	Board
Review limit and stress reports	Board committee
Set daily desk limits	Management
Build models, price trades	Management

IN THE LESSON

- Here is the dividing line that is easy to blur.
- Setting the risk appetite is the board's job.
- Building the framework and the systems to stay within it is management's job, and the board checks that it is capable.
- Approving the strategy belongs to the board; executing it belongs to management.
- Reviewing reports on breaches is the board; setting daily desk limits, building models and pricing individual trades belong to management.
- The common mistake is to confuse oversight with management.
- If a question describes directors approving an individual trade or building the model, it describes a board doing management's work, and that is not oversight.

17 Risk appetite: how much risk, and of what kind

- Appetite = amount and type of risk accepted for strategy
- It must sit below risk capacity (the cliff edge)
- Set by the board, in measurable terms
- Cascaded into limits for each business unit

IN THE LESSON

- Now risk appetite, and how it connects to strategy.
- Risk appetite is the aggregate amount and type of risk a firm is willing to accept to pursue its strategy.
- Strategy comes first: a firm that wants to grow in lending must be willing to take credit risk.
- Appetite follows.
- It must sit below risk capacity, which is the maximum loss the firm could absorb before breaching its capital, liquidity or rating constraints.
- Capacity is the cliff edge; appetite is where you choose to walk, with a margin.
- A good risk appetite statement is set by the board and expressed in measurable terms, such as capital ratios, earnings at risk, value at risk or concentration limits, then cascaded into limits for each business unit.

18 Case 2: from capacity to appetite to limits

Illustration: maximum acceptable loss in a bad year, $ millions

Risk capacity	loss before constraints breached	**800**
Risk appetite	set by the board	**500**
Buffer	800 − 500	**300**
Unit limits	200 + 250 + 50	**500**
Check	limits = appetite < capacity	**OK**

IN THE LESSON

- Take a firm and illustrate the cascade.
- Suppose the most loss it could absorb before breaching its capital constraint, its risk capacity, is eight hundred million dollars.
- The board sets its risk appetite, the loss it is willing to accept in a bad year, at five hundred million.
- That leaves a buffer of three hundred million between appetite and capacity.
- The appetite is then cascaded into limits for units: two hundred million for trading, two hundred and fifty for lending, and fifty for everything else.
- Add them: two hundred plus two hundred and fifty plus fifty is five hundred, which fits within the appetite.
- The check to remember is that the unit limits must be consistent with the appetite, and the appetite must be below capacity.

19 Incentives: why pay can undo the appetite

- Upside without downside pushes staff past the appetite
- Revenue bonuses and options reward risk-taking
- Fix: judge units on risk-adjusted measures
- Add deferral and clawback

IN THE LESSON

- Why do incentives belong in a lesson on appetite?
- Because pay with upside but limited downside pushes staff beyond the intended appetite.
- A bonus based on revenue, or stock options, pays well if the bet works, and costs the employee little if it fails.
- Think of a coin flip where heads wins a large prize and tails costs nothing: you would take as many flips as you could.
- The firm bears the tails.
- Aligned pay uses risk adjusted measures, so a unit is judged on return after a charge for the risk.
- It adds deferral, meaning part of the pay is held back for years, and clawback, meaning pay already given can be taken back if losses later emerge.

20 RAROC: a risk-adjusted measure

RAROC = (revenue − costs − expected loss) ÷ economic capital

Revenue	What the unit earns
Costs	Running costs of the unit
Expected loss	Average loss expected on positions
Econ. capital	Capital held against bad surprises
RAROC	Return per unit of risk capital

IN THE LESSON

- The common risk adjusted measure in the course is R A R O C, which stands for risk adjusted return on capital.
- The top of the fraction starts with revenue and subtracts two things.
- First costs, the running costs of the unit.
- Second expected loss, the average loss the unit should suffer from its positions, such as the credit losses a lender expects.
- What remains is the return after paying for normal losses.
- The bottom is economic capital, the capital the unit needs to survive unexpected losses.
- So R A R O C asks how much return the unit earns for each dollar of capital that its risk uses up.
- The common error is to judge units on return before expected loss and before capital, which ignores risk altogether.

21 Case 3: two units, one looks better

Illustration, $ millions: revenue, costs, expected loss, capital

Unit A: 120 − 50 − 10	RAROC = 60 ÷ 200	**30%**
Unit B: 150 − 60 − 30	RAROC = 60 ÷ 400	**15%**
Higher revenue	B: 150, A: 120	**B**
Higher RAROC	A: 30%, B: 15%	**A**

IN THE LESSON

- Let us compare two units, using illustrative figures in millions of dollars.
- Unit A has revenue of one hundred and twenty, costs of fifty, expected loss of ten, and economic capital of two hundred.
- Its top line is one hundred and twenty minus fifty minus ten, which is sixty.
- Sixty over two hundred is thirty per cent.
- Unit B has revenue of one hundred and fifty, costs of sixty, expected loss of thirty, and economic capital of four hundred.
- Its top line is one hundred and fifty minus sixty minus thirty, which is sixty as well.
- Sixty over four hundred is fifteen per cent.
- Unit B has bigger revenue, yet half the return on capital.
- A revenue bonus would favour B.
- A R O C says A earns more per dollar of risk capital, so on this measure A is the better use of capital, though both should still be compared with the firm's required return.

22 Functional units that risk management relies on



IN THE LESSON

- Risk management only works when the firm's functional units rely on one another.
- Look at the picture.
- In the top row are the units that feed risk management.
- Operations and technology supply the position data.
- Finance supplies verified valuations through independent price verification.
- Legal reviews documentation, for instance whether netting agreements, which let you offset what you owe against what you are owed, are enforceable.
- In the bottom row are the units that shape and test the system.
- Treasury manages funding and liquidity.
- Human resources and the compensation committee shape incentives.
- Internal audit tests the whole system.
- Compliance monitors rules.
- Weak links in any unit become risk events elsewhere.

23 Case 4: a failure that spreads between units

Illustration: a position marked by the desk, $ millions

Desk's own mark	no independent check	**100**
Independent price verification	found by a separate unit	**92**
Overstatement	100 − 92	**8**
Overstated share of mark	8 ÷ 100	**8%**
Knock-on effects	market, credit, profit, pay	**All wrong**

IN THE LESSON

- A useful exercise is to trace a chain.
- Take a desk that marks its own positions, with no independent price verification.
- The traders value a position at one hundred million, when an independent check would have found ninety two.
- So the position is overstated by eight million, or eight per cent of the reported value.
- Risk management measures market risk from that inflated value, so the value at risk number is wrong.
- Credit risk is misstated too, since the exposure to a counterparty on the position is misjudged.
- Finance reports profit that does not exist, and the bonus pool is paid on it.
- One weak link, traders marking their own books, has become a market risk problem, a credit risk problem, a reporting problem and a pay problem.

24 Treasury, legal and compliance: more links in the chain

- Treasury: funding, liquidity, funds transfer prices
- Cheap internal funding makes a unit look better than it is
- Legal: enforceable netting and documentation
- Compliance monitors rules, HR shapes incentives

IN THE LESSON

- A few more links deserve a closer look.
- Treasury manages funding and liquidity, and it sets internal funds transfer prices, the rates at which business units are charged for the money they use and credited for the funding they raise.
- If the transfer price is too low, a unit looks profitable because it is borrowing cheaply from inside the firm, and it will build too much of the position.
- So the price shapes behaviour.
- Legal checks that contracts are enforceable, which feeds the credit risk numbers.
- Compliance monitors rules and regulations.
- Human resources and the compensation committee shape the incentives we have just studied.
- Internal audit tests whether the whole system, including these links, actually works.

25 The audit committee

- Independent directors, one a financial expert
- Oversees financial statements and internal controls
- Oversees internal audit and the external auditor
- Judges auditor independence, pre-approves non-audit work

IN THE LESSON

- The last part is the audit committee.
- It is a committee of the board.
- Under common good practice, and in many listed company regimes, it is made up of independent directors, with at least one who has financial expertise, though requirements vary by jurisdiction.
- Its core duties concern the integrity of the numbers: the integrity of the financial statements, the effectiveness of internal controls over financial reporting, the internal audit function, and the external auditor.
- In many jurisdictions it appoints and pays the external auditor.
- It typically judges the auditor's independence and pre approves non audit services, so the auditor is not tempted to protect a lucrative consulting contract.
- Internal audit reports functionally to it.

26 More duties of the audit committee

- Receives internal audit reports directly
- Meets auditors without management present
- Handles whistleblower complaints
- Tracks management's fixes of audit findings

IN THE LESSON

- The committee does more.
- It receives internal audit reports directly, because in good practice internal audit reports functionally to it, and not to the managers being audited.
- It meets the auditors without management present, so they can speak freely.
- It handles whistleblower complaints, giving staff a safe route to report concerns about accounting or controls.
- It oversees compliance with law and regulation.
- And it tracks management's remediation of audit findings, meaning it checks that problems found are actually fixed, not just noted.
- What it does not do is set risk appetite or run risk models.
- Those belong to the board and its risk committee, and to management.
- The audit committee watches the integrity of reporting and control.

27 Audit committee against risk committee

Both are board committees; the duties differ

Duty	Committee
Review risk appetite and limits	Risk committee
Review stress tests, breaches	Risk committee
Appoint, pay external auditor	Audit committee
Oversee internal audit, controls	Audit committee
Whistleblower complaints	Audit committee

IN THE LESSON

- A common trap here is confusing the audit committee with the risk committee.
- Use this table.
- The risk committee advises the board on risk appetite and risk strategy, and reviews limits, stress tests and breaches.
- The audit committee oversees financial reporting, internal controls over that reporting, internal audit and the external auditor.
- Who appoints and pays the external auditor, in many jurisdictions?
- The audit committee.
- Who recommends or reviews the risk appetite statement?
- The risk committee, for the board.
- Who handles whistleblower complaints?
- The audit committee.
- Who reviews stress test results?
- The risk committee.
- Both are board committees of independent directors, and that is why they get mixed up, but their jobs differ.

28 Four mistakes to avoid

- Oversight is not management
- Risk must not report to or be paid by desks
- Judge units after expected loss and capital
- Audit committee is not the risk committee

IN THE LESSON

- Here are four mistakes to avoid.
- First, confusing oversight with management.
- The board approves appetite and challenges; it does not set daily desk limits or build models.
- Second, accepting a risk function that reports to, or is paid from, the units it monitors.
- Independence in reporting and pay is the heart of good governance.
- Third, judging units on return before expected loss and capital.
- Use a risk adjusted measure such as R A R O C, with deferral and clawback.
- Fourth, mixing up the audit committee and the risk committee.
- Audit looks at the integrity of financial reporting, controls and auditors; the risk committee looks at appetite, limits and stress tests.
- Avoid these and you will sidestep the commonest errors.

29 Recap: governance in one page

- Crisis: governance failed; reforms match weaknesses
- Best practice: appetite, senior CRO, three lines
- Board oversees; appetite below capacity; pay risk-adjusted
- Units interdepend; audit guards reporting

IN THE LESSON

- Let us pull it together.
- The crisis exposed governance failures as much as model failures: siloed risk, weak chief risk officers, thin board expertise and pay without a charge for risk, plus calm period V a R.
- The reforms answered them one by one, from Dodd-Frank and Basel three to deferred pay and stressed V a R.
- Best practice rests on a board approved appetite, an independent senior chief risk officer, three lines of defence, limits and independent validation.
- The board oversees; management runs.
- Appetite sits below capacity and flows into limits, and pay must be risk adjusted.
- Functional units depend on each other.
- And the audit committee guards the integrity of reporting, controls and the auditors.

30 Try three quick questions

1. Revenue 100, costs 40, expected loss 10, capital 200. RAROC?
   Answer: (100 − 40 − 10) ÷ 200 = 25%.
2. Which crisis weakness did the Volcker Rule answer?
   Answer: Proprietary trading by banks.
3. Which committee appoints and pays the external auditor?
   Answer: The audit committee, in many jurisdictions.

IN THE LESSON

- Now try three quick questions yourself.
- Pause after each one.
- Question one.
- A unit has revenue of one hundred, costs of forty, expected loss of ten and economic capital of two hundred.
- What is its R A R O C?
- One hundred minus forty minus ten is fifty.
- Fifty over two hundred is twenty five per cent.
- Question two.
- Which crisis weakness did the Volcker Rule answer?
- Proprietary trading, meaning banks trading their own money for their own profit.
- Question three.
- Which committee appoints and pays the external auditor in many jurisdictions?
- The audit committee, not the risk committee, which instead reviews appetite, limits and stress tests.