CHARTA LEARNING · LESSON NOTES

Stress Testing Banks

FRM Part II

1 A story: the bank that tested the wrong storm

- Monthly desk shocks: rates up, equities down
- Losses look small; the board relaxes
- Recession: loans, markets and income hit together
- The test was too narrow, not wrong
- Modern test: whole bank's capital over a horizon

IN THE LESSON

- Imagine Fenwick Bank before a crisis.
- Every month its traders shock their positions: rates up a full point, equities down twenty per cent, and they report the loss.
- The numbers look small, so the board relaxes.
- Then a recession arrives.
- House prices fall, unemployment rises, loans go bad and markets drop at the same time, and the losses land on the whole bank, not just the trading desk.
- The test was not wrong, it was too narrow.
- A modern stress test asks what a coherent, severe scenario does to the whole bank's capital, over a horizon of a couple of years or so, including its income, its losses and its payouts.

2 Where stress testing began

- Internal tool, mostly for trading books
- Stylised shocks applied beside VaR
- 1996 Basel market risk amendment expected them
- Limits: own shocks, not comparable across banks
- Trading book only; not tied to capital

IN THE LESSON

- Stress testing began as an internal risk tool, mostly for trading books.
- Value at risk, written V a R, estimates the loss that should be exceeded only rarely, say on one day in a hundred, using recent market behaviour.
- Traders and risk managers knew that V a R says little about extreme days, so beside it they applied stylised shocks: simple, round moves such as a large rise in rates or a crash in equities.
- The nineteen ninety six Basel market risk amendment expected banks to run such stress tests.
- But these tests had limits.
- Each bank chose its own shocks, so results could not be compared.
- They covered the trading book, not the loan book.
- And they were not tied to the bank's capital.

3 From desk tool to supervisory exercise

Stress testing moved from the trading desk to the supervisor

When	What changed
Before 2007	Internal tool, mostly trading books
2007 to 2009	Crisis: capital after a recession unknown
2009: SCAP (US)	Became a supervisory capital exercise
From 2011: CCAR (US)	Annual Federal Reserve review
EBA (EU)	EU-wide tests, common methodology

IN THE LESSON

- The table traces the turn.
- Before the crisis, stress tests were internal and run mainly on trading books.
- The financial crisis of two thousand and seven to two thousand and nine showed that supervisors, investors and even banks themselves did not know how much capital the banks would have left after a deep recession.
- In two thousand and nine, the American S C A P made stress testing a supervisory capital exercise.
- From two thousand and eleven, the C C A R made it an annual review in the United States.
- In Europe, the E B A ran E U wide tests on a common methodology.
- The idea moved from what a desk might lose tomorrow to how much capital a whole bank keeps through a recession.

4 SCAP: the 2009 Supervisory Capital Assessment Program

- 19 largest US bank holding companies
- Common baseline and adverse macro scenarios
- Bank estimates combined with supervisors' own
- Bank-level results published
- A public capital backstop

IN THE LESSON

- Let us look at each exercise in turn, starting with S C A P, the Supervisory Capital Assessment Program of two thousand and nine.
- It covered the nineteen largest American bank holding companies.
- A bank holding company is the parent company that owns a bank.
- Every bank faced the same two macroeconomic scenarios, a baseline and an adverse one, so results could be compared.
- Projections combined the banks' own estimates with the supervisors' own estimates, so no bank simply marked its own homework.
- The results were published bank by bank.
- And it came with a public capital backstop: if a bank could not raise the capital it needed from private investors, public money stood behind it.

5 Why SCAP calmed the market

- Nobody knew how deep bank losses would run
- Bank-by-bank results replaced rumour with numbers
- A shortfall with no backstop could trigger a run
- The backstop meant any gap would be filled
- Supervisory estimates made the numbers believable

IN THE LESSON

- Why did S C A P matter so much?
- In the crisis, nobody trusted bank balance sheets, because nobody knew how deep the losses would run.
- Publishing bank by bank results replaced rumour with numbers.
- But publishing a capital shortfall can be dangerous on its own.
- If investors learn that a bank is short of capital and nobody will fill the gap, they may run.
- The public backstop removed that danger, because any shortfall would be filled one way or another.
- And the supervisors' own estimates made the numbers more believable than figures a bank had produced alone.
- So three features worked together: common scenarios, supervisory estimates, and disclosure backed by a backstop.
- Fenwick, as one of the large banks, would have had nowhere to hide.

6 CCAR: the annual capital plan review

- Comprehensive Capital Analysis and Review
- Annual Federal Reserve exercise, from 2011
- SCAP was a one-off; CCAR is recurring
- Judges the whole capital plan
- Including dividends and share buybacks

IN THE LESSON

- The next step was C C A R, the Comprehensive Capital Analysis and Review, an annual Federal Reserve exercise from two thousand and eleven.
- S C A P had been a one off rescue in a crisis.
- C C A R made the test a regular part of supervision.
- The key difference is what it judges.
- C C A R looks not only at projected losses but at the bank's whole capital plan, including the dividends it wants to pay to shareholders and the buybacks, which are purchases of its own shares.
- Both send capital out of the bank.
- So if Fenwick plans generous payouts, the Federal Reserve asks whether its capital would still be adequate in the stress scenario after those payouts.
- The result shapes how much capital a bank may return to shareholders.

7 The EBA's EU-wide tests

- European Banking Authority (EBA)
- Mainly bank-run and bottom-up
- Bottom-up: each bank uses its own models
- A common methodology keeps results comparable
- Static balance sheet: the bank is frozen at the start

IN THE LESSON

- In Europe, the E B A, the European Banking Authority, ran E U wide stress tests.
- The earlier E B A tests were mainly bank run and bottom up.
- Bottom up means each bank runs the scenario through its own models, loan by loan and position by position.
- Top down means the supervisor runs its own models across all banks.
- To keep the results comparable, banks followed a common methodology.
- And they assumed a static balance sheet.
- That means the bank is frozen as it was at the start: a loan that matures is replaced by a similar one, and the bank does not grow, shrink or change its business mix during the test.

8 Comparing the three exercises

Ask: who models, what is distinctive, what is the result used for?

	SCAP 2009	CCAR	EBA
Who models	Banks + supervisors	Banks + Fed	Banks, bottom-up
Distinctive	Public backstop	Whole capital plan	Static balance sheet
Used for	Crisis capital buffers	Judging payouts	EU-wide comparison

IN THE LESSON

- Here is the comparison the exam wants.
- Read across each row.
- Who models?
- In S C A P, the banks and the supervisors both did.
- In C C A R, the banks and the Federal Reserve both project.
- In the E B A tests, mainly the banks, bottom up.
- What is distinctive?
- S C A P had the public backstop.
- C C A R judges the whole capital plan.
- The E B A held the balance sheet static.
- What was the result used for?
- S C A P sized the capital buffers banks needed in the middle of a crisis, with published results.
- C C A R decides whether planned payouts are acceptable.
- The E B A tests gave a comparable E U wide picture of bank capital.
- The exam point: separate who models, what is distinctive, and what the result is used for.

9 Example 1: which exercise is it?

Match each description to the exercise it describes

Common scenarios, public backstop	19 largest US banks	**SCAP**
Annual; judges planned dividends	Federal Reserve	**CCAR**
Banks model, common rule book	static balance sheet	**EBA**
Stylised shocks beside VaR	trading desks	**Internal tool**

IN THE LESSON

- Let us test that with four short descriptions.
- First, common scenarios for the nineteen largest American banks, with a public backstop.
- That is S C A P.
- Second, an annual review in which the Federal Reserve judges whether a bank's planned dividends are acceptable.
- That is C C A R.
- Third, banks run the scenario through their own models under a common rule book, and the balance sheet is held static.
- That is the E B A.
- Fourth, stylised shocks applied beside V a R on trading desks.
- That is the older internal tool, from before stress testing became a supervisory exercise.
- The trap on the exam is to mix up the E B A's bank run, static approach with C C A R's review of the whole capital plan.

10 A scenario must be coherent

- Risk factor: a variable that drives results
- Scenario: values for all the factors at once
- Coherent: factors move as the economy could
- Recession: house prices down, jobless up, stocks down
- An incoherent scenario gives meaningless losses

IN THE LESSON

- Now to building the scenario itself.
- A risk factor is a market or economic variable that drives the bank's results, such as house prices, an equity index, unemployment or interest rates.
- A scenario is a set of values for all of those factors at once.
- The central difficulty is coherence.
- A coherent scenario is one in which the risk factors move together in a way the economy and markets could actually produce.
- In a recession, house prices fall, unemployment rises and equities drop, all at once.
- A scenario in which house prices crash while unemployment falls and equities boom is hard to believe.
- Its losses would be meaningless, however precisely they were computed.

11 The trap: worst value for every factor

- Worst value for each factor, then add the losses
- Ignores co-movement between factors
- The worst moves never happened together
- Offsetting positions make the sum misleading
- Goal: severe and coherent at the same time

IN THE LESSON

- The most tempting mistake is to shock each factor to its own worst value and add up the losses.
- It feels safe, but it ignores co-movement, the way factors move together.
- Each factor's worst move happened on a different day, in a different crisis, so the worst moves never happened together.
- The result is a scenario that may lie far from anything that could happen.
- It can also mislead in a quieter way: if some positions offset others, the worst move for one factor may push another in a direction that helps, and adding separate worst cases misses that.
- So the summed figure is neither a sound measure of risk nor a reliable upper limit to rely on.
- A good scenario is severe and coherent at the same time.

12 Historical and hypothetical scenarios

Each type of scenario solves one problem and leaves another

	How built	Coherent?	Relevant?
Historical	Replays a real episode	Yes, by construction	May not fit today
Hypothetical	Designed for today	Harder to ensure	Yes, by design

IN THE LESSON

- There are two main ways to build a scenario, and each has a weakness.
- A historical scenario replays a real episode, such as the moves in a past crisis.
- It is coherent by construction, because those moves really happened together.
- But it may not be relevant to today's portfolio: the bank may hold different assets now, and the next crisis may look different.
- A hypothetical scenario is designed for today's risks.
- Its coherence is harder to ensure, because the designer has to decide how every factor moves, and the human eye is poor at judging joint moves.
- But it is relevant by design.
- The practical answer for hypothetical scenarios is on the next slide.

13 Shock a few, condition the rest

Target = μY + ρ × (σY ÷ σX) × (x − μX)

Normal level of Y	Mean of Y
Correlation of X and Y	Between −1 and +1
Volatility ratio σY ÷ σX	Converts X units into Y units
Size of the shock to X	x − μX: how far X is pushed

IN THE LESSON

- A common fix is to shock a few key factors, chosen for the story, and set every other factor at its conditional expectation, meaning its average value given the shock.
- Let X be the shocked factor and Y another factor.
- Mu Y is the normal level of Y, its mean.
- Rho is the correlation of X and Y.
- Sigma Y over sigma X, the ratio of their standard deviations, converts a move in X into the units of Y.
- And x minus mu X is the size of the shock to X, measured from its mean.
- If the factors are jointly normal, the target for Y equals mu Y plus rho, times sigma Y over sigma X, times x minus mu X.
- A strongly correlated factor moves a lot, and an unrelated one stays near its mean.

14 Example 2: conditioning on a house price crash

House prices: mean 3%, SD 8%, shocked to −21%. Set the others at their conditional mean

Shock to house prices	−21 − 3 = −24 points	**−3.0 SD**
Equities: mean 7, SD 18, ρ 0.6	0.6 × (18 ÷ 8) × −24	**−32.4 points**
Equity target	7 − 32.4	**−25.4%**
Unemployment: 5, 1.5, ρ −0.7	5 + (−0.7) × (1.5 ÷ 8) × −24	**8.15%**

IN THE LESSON

- Fenwick's risk team shocks house prices.
- Their annual change has a mean of three per cent and a standard deviation of eight.
- The shock is a fall of twenty one per cent, which is twenty four points below the mean, or three standard deviations.
- Equities have a mean of seven per cent, a standard deviation of eighteen, and a correlation of point six with house prices.
- Their target is seven, plus point six times eighteen over eight, times minus twenty four, which is seven minus thirty two point four, giving minus twenty five point four per cent.
- Unemployment has a mean of five per cent, a standard deviation of one and a half, and a correlation of minus point seven.
- Its target is five plus three point one five, which is eight point one five per cent.

15 Example 3: coherent loss versus the worst of each

Loss: $30m per SD fall in house prices, $20m per SD fall in equities

Equity move in SDs	(−25.4 − 7) ÷ 18	**−1.8 SD**
Coherent loss	30 × 3 + 20 × 1.8	**$126m**
Worst of each: both −3 SD	30 × 3 + 20 × 3	**$150m**
Difference	150 − 126	**$24m**

IN THE LESSON

- Now the losses.
- Suppose Fenwick loses thirty million dollars for each standard deviation that house prices fall, through its mortgages, and twenty million for each standard deviation that equities fall, through its trading book.
- In the coherent scenario, house prices fall three standard deviations.
- Equities fall to minus twenty five point four, which is thirty two point four below their mean of seven, or one point eight standard deviations.
- The loss is ninety plus thirty six, one hundred and twenty six million dollars.
- Adding the worst of each instead, three standard deviations on both, gives ninety plus sixty, one hundred and fifty million.
- The extra twenty four million comes from a joint move that the correlation says is less likely than the coherent one.

16 How plausible is a scenario? The Mahalanobis distance

Straight line (ρ = 0): D = √(zX^2 + zY^2)
D^2 = (zX^2 + zY^2 − 2ρ × zX × zY) ÷ (1 − ρ^2)

Standard scores of the moves	Moves in standard deviations
Correlation of the factors	Rho, between −1 and +1
Distance from normal times	Larger D: less plausible

IN THE LESSON

- How far from normal times is a scenario?
- Plausibility can be measured by the Mahalanobis distance, which accounts for correlation.
- First turn each factor's move into a standard score: its distance from its mean in standard deviations, written z X and z Y.
- With no correlation, the distance would be the ordinary straight line distance, the square root of z X squared plus z Y squared.
- With correlation rho, a joint move in the expected direction counts for less, and a move against the correlation counts for more.
- For two factors, D squared equals z X squared plus z Y squared minus two rho z X z Y, all divided by one minus rho squared.
- A larger distance means a less plausible scenario.

17 Example 4: three scenarios, measured

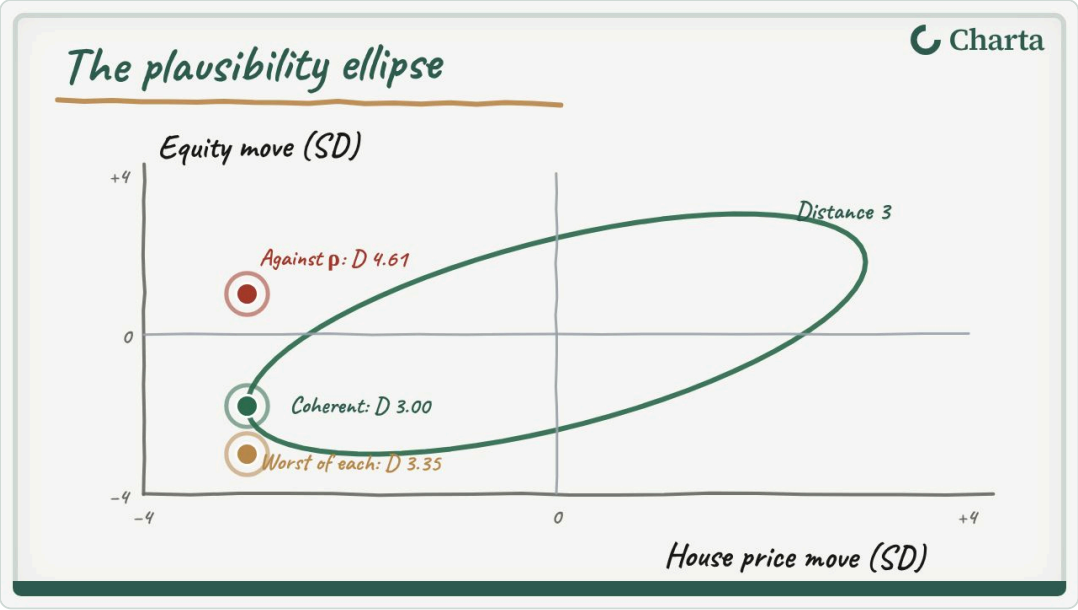
Correlation 0.6. Distance of each scenario from normal times

Coherent: zX −3, zY −1.8	(9 + 3.24 − 6.48) ÷ 0.64	**D = 3.00**
Worst of each: −3, −3	(9 + 9 − 10.8) ÷ 0.64	**D = 3.35**
Against ρ: −3, +1	(9 + 1 + 3.6) ÷ 0.64	**D = 4.61**
Straight line: −3,−3 vs −3,+1	√18 vs √10	**4.24 vs 3.16**

IN THE LESSON

- Let us measure three scenarios for Fenwick, with a correlation of point six.
- The coherent one has z X of minus three and z Y of minus one point eight.
- D squared is nine plus three point two four minus six point four eight, which is five point seven six, over point six four, giving nine.
- So D is exactly three, the same as the three standard deviation shock to house prices measured on its own.
- Setting equities at their conditional expectation adds nothing to the distance.
- The worst of each, minus three and minus three, gives nine plus nine minus ten point eight, over point six four, so D is three point three five.
- A scenario against the correlation, house prices down three but equities up one, gives nine plus one plus three point six, over point six four, so D is four point six one.
- The ordinary straight line distance gets the order wrong: four point two four against three point one six.

18 The plausibility ellipse



IN THE LESSON

- Here is the picture.
- Along the bottom is the house price move in standard deviations, and up the side is the equity move, both from minus four to plus four.
- The two grey guides mark zero on each axis, the normal state.
- The green oval is every scenario at a Mahalanobis distance of exactly three.
- It is tilted because the factors are positively correlated, so moving together is easier than moving apart.
- The green dot is the coherent scenario, sitting on the oval.
- The orange dot, the worst of each, lies a little outside it.
- The red dot, house prices down but equities up, lies far outside.
- Among all scenarios with a house price fall of three standard deviations, the conditional expectation is the one closest to normal times.

19 When the models break

- Turning a scenario into losses needs models
- Models are fitted mostly on calm-period data
- Stress asks them to extrapolate to extreme paths
- Relationships can jump; correlations rise in crises
- Challenge extreme-path output with judgment

IN THE LESSON

- Even a coherent scenario has to be turned into losses, and that needs models.
- Here lies a further difficulty.
- Most models linking the economy to defaults and revenues are fitted in calm periods, because that is where most of the data lies.
- A stress scenario asks them to extrapolate, that is, to predict far outside the range they were fitted on.
- Relationships can break down there.
- A loss rate that rose gently with unemployment in normal times may jump once a threshold is crossed.
- Correlations themselves tend to rise in a crisis, so a scenario conditioned on calm period correlations may understate how far the other factors move.
- The lesson is to treat model output under extreme paths with care, and to challenge it with judgment.

20 Projecting capital, not just losses

- Forecast capital, not just losses
- Revenue and costs: pre-provision net revenue
- Losses: provisions and market losses
- Distributions: dividends and buybacks
- Risk-weighted assets, the denominator, also move

IN THE LESSON

- Suppose Fenwick has its scenario.
- The next job is to project the whole bank across the stress horizon, and that means forecasting capital, not just losses.
- A loss of seven billion dollars might sink one bank and barely trouble another.
- What matters is what the bank earns along the way, what it pays out, and how large its balance sheet becomes.
- So the projection has four parts.
- Revenue and costs give pre provision net revenue.
- Losses arrive through provisions and market losses.
- Distributions, the dividends and buybacks, take capital out.
- And risk weighted assets, the denominator of the capital ratio, move as well.
- Risk weighted assets, written R W A, are the bank's assets scaled by how risky each one is.

21 The ending capital ratio

Ratio = (Start + PPNR − Losses − Payouts) ÷ RWA
PPNR = net interest income + fees − non-interest expense

Capital at the start	Before the stress begins
Pre-provision net revenue	Operating profit before provisions
Provisions and market losses	Credit provisions + market losses
Dividends and buybacks	Capital paid out
Projected risk-weighted assets	Projected, not today's

IN THE LESSON

- Here is the formula that ties it together.
- Start is capital at the beginning of the horizon.
- P P N R is pre provision net revenue, which is net interest income plus fees, minus non interest expense, the bank's operating profit before it sets aside anything for loan losses.
- Losses are the provisions for credit losses and any market losses, such as falls in the value of the trading book.
- Payouts are dividends and buybacks.
- Ending capital is start plus P P N R minus losses minus payouts.
- The ending capital ratio divides that by projected R W A at the end of the horizon.
- For simplicity in this lesson we ignore taxes.
- The exam point is that the denominator moves too.

22 Example 5: Fenwick's pre-provision net revenue

Fenwick, totals over the stress horizon, $bn

Net interest income (NII)		**$9.0bn**
Fees		**$4.0bn**
Non-interest expense		**$8.0bn**
PPNR	9.0 + 4.0 − 8.0	**$5.0bn**
PPNR if NII is 10% lower	8.1 + 4.0 − 8.0	**$4.1bn**

IN THE LESSON

- Let us build Fenwick's projection, in billions of dollars, summed over the whole horizon.
- Net interest income, written N I I, is the interest earned on loans and securities minus the interest paid on deposits and debt.
- It is nine billion.
- Fees are four billion.
- Non interest expense, mainly staff, premises and technology, is eight billion.
- So P P N R is nine plus four minus eight, five billion dollars.
- Now see how fragile that is.
- If a different path for interest rates squeezes net interest income by ten per cent, to eight point one billion, then P P N R falls to four point one billion.
- The losses have not changed at all, yet Fenwick has nine hundred million dollars less capital at the end.

23 Why revenue is harder than losses

- Losses: long loss histories by segment
- Revenue: few stressed observations
- Revenue depends on strategy and pricing
- Net interest income depends on the rate path
- A small revenue error can rival a large loss error

IN THE LESSON

- That example shows why revenue is the harder half.
- Losses are easier to project, because banks hold long loss histories by segment, such as mortgages, credit cards and commercial property, and those histories include past recessions.
- Revenue is harder for three reasons.
- First, there are few stressed observations: a bank may have lived through only one or two deep recessions with its current business.
- Second, revenue depends on the bank's own strategy and pricing, which managers change as conditions change.
- Third, net interest income depends on the path of interest rates, and on how fast deposit rates follow market rates.
- A small error in revenue can rival a large error in losses.

24 Example 6: provisions include the reserve build

Fenwick over the horizon: charge-offs $5bn; allowance $6bn at start, $8bn at end

Charge-offs	loans written off	**$5.0bn**
Change in allowance	8.0 − 6.0	**$2.0bn**
Provision expense	5.0 + 2.0	**$7.0bn**
Wrong: charge-offs only	misses the build	**$5.0bn**

IN THE LESSON

- Next, the provisions.
- Provision expense equals charge offs plus the change in the loan loss allowance.
- A charge off is a loan written off as uncollectible.
- The allowance is the reserve set aside on the balance sheet for future credit losses.
- Over the horizon, Fenwick charges off five billion dollars.
- But at the end of the horizon the economy is still weak, and Fenwick expects more losses beyond it, so its allowance must rise from six billion to eight billion.
- That build of two billion is also an expense.
- The provision is five plus two, seven billion dollars.
- The trap is to subtract only the charge offs.
- A reserve build for losses beyond the horizon also hits capital.

25 Example 7: Fenwick's ending capital

Fenwick: start capital $13bn, RWA $100bn (ratio 13.0%). Amounts over the horizon, $bn

Start capital	13.0 ÷ 100 = 13.0%	**$13.0bn**
Add PPNR		**+$5.0bn**
Less provisions and market losses	7.0 + 1.0	**−$8.0bn**
Less payouts	dividends and buybacks	**−$1.5bn**
Ending capital	13 + 5 − 8 − 1.5	**$8.5bn**

IN THE LESSON

- Now we put the pieces together.
- Fenwick starts with capital of thirteen billion dollars against risk weighted assets of one hundred billion, a ratio of thirteen per cent.
- It adds P P N R of five billion.
- It subtracts provisions of seven billion and market losses of one billion.
- It plans dividends and buybacks of one and a half billion.
- Ending capital is thirteen plus five, minus seven, minus one, minus one and a half, which is eight and a half billion dollars.
- Notice how the pieces line up.
- Income covered most of the provisions, leaving a gap of two billion dollars.
- The market losses of one billion and the payouts of one and a half billion added to that gap.
- Capital has fallen by four and a half billion.
- The next question is what ratio that gives.

26 Example 8: the denominator moves too

Ending capital $8.5bn. Board's own target: at least 8.5% (made up)

Static: RWA stay at 100	8.5 ÷ 100	**8.5%**
Dynamic: RWA rise to 105	8.5 ÷ 105	**8.1%: below**
Cancel payouts	(8.5 + 1.5) ÷ 105	**9.5%**
Wrong: forget reserve build	(8.5 + 2.0) ÷ 105	**10.0%**

IN THE LESSON

- Fenwick's board wants a ratio of at least eight and a half per cent at the low point, a made up target for this example.
- With a static balance sheet, R W A stays at one hundred billion, and the ratio is eight point five per cent, just on target.
- But in a recession borrowers draw on their credit lines and loans migrate to worse ratings, so suppose R W A rise to one hundred and five billion.
- The ratio is eight point five over one hundred and five, eight point one per cent, below target.
- If Fenwick cancels its payouts, a management action, capital is ten billion and the ratio is nine point five per cent.
- Had it forgotten the reserve build, the ratio would have looked like ten per cent.

27 Static or dynamic balance sheet?

Each choice trades simplicity against realism

	Static	Dynamic
Idea	Frozen at the start	Changes over the horizon
Strength	Simple, comparable	More realistic
Weakness	Ignores drawdowns, funding	Needs many assumptions
Misses / requires	Management actions	Consistent with scenario

IN THE LESSON

- This brings us to the choice of balance sheet.
- A static balance sheet, as in the earlier E B A tests, freezes the bank as it was at the start.
- It is simple and comparable across banks.
- But it ignores what really happens in a stress: drawdowns on credit lines, funding strains as depositors or lenders pull back, and management actions such as cutting payouts or selling assets.
- A dynamic balance sheet lets the bank change through the horizon.
- It is more realistic, but it needs assumptions, and those assumptions must be consistent with the scenario.
- A bank cannot assume strong loan growth and easy funding in a deep recession.
- Fenwick's dynamic projection must explain where its extra R W A come from.

28 Mistakes to avoid

- Mixing up SCAP, CCAR and the EBA tests
- Worst value for every factor: ignores co-movement
- Straight-line distance: use Mahalanobis instead
- Charge-offs only: the reserve build hits capital too
- RWA held at today's level: the denominator moves

IN THE LESSON

- Before the quiz, here are the mistakes examiners look for.
- First, mixing up the exercises: the E B A tests were bank run and static, C C A R judges the whole capital plan including payouts, and S C A P combined bank and supervisory estimates with a public backstop.
- Second, building a scenario from the worst value of every factor, which ignores co-movement.
- Third, using the ordinary straight line distance to judge plausibility, when the Mahalanobis distance accounts for correlation.
- Fourth, subtracting only charge offs, and forgetting that a reserve build also hits capital.
- Fifth, holding R W A fixed at today's level when the stress would push them up.
- Remember: the denominator moves too.

29 Try three quick questions

1. X: mean 2%, SD 4%, shocked to −10%. Y: mean 1%, SD 3%, ρ 0.5. Target for Y?
   Answer: 1 + 0.5 × (3 ÷ 4) × (−12) = −3.5%.
2. Start $10bn, PPNR $3bn, losses $5.5bn, payouts $0.5bn, RWA $80bn. Ending ratio?
   Answer: (10 + 3 − 5.5 − 0.5) ÷ 80 = 7 ÷ 80 = 8.75%.
3. Which exercise was mainly bank-run, bottom-up, with a static balance sheet?
   Answer: The EBA's EU-wide stress tests.

IN THE LESSON

- Now try three quick questions.
- Pause the video, think, then listen to the answers.
- Question one.
- Factor X has a mean of two per cent and a standard deviation of four, and it is shocked to minus ten per cent.
- Factor Y has a mean of one per cent, a standard deviation of three, and a correlation of point five with X.
- What is the conditional target for Y?
- The shock is minus twelve points, so the target is one plus point five times three quarters times minus twelve, which is minus three point five per cent.
- Question two.
- Capital starts at ten billion.
- P P N R is three billion, losses are five and a half billion, payouts are half a billion, and projected R W A are eighty billion.
- What is the ending ratio?
- Ending capital is seven billion, so the ratio is eight point seven five per cent.
- Question three.
- Which exercise was mainly bank run and bottom up, with a static balance sheet?
- The E B A's E U wide tests.