CHARTA LEARNING · LESSON NOTES

Insurance Companies and Pension Plans

FRM Part I

1 A story: a promise that lasts forty years

- Insurer: paid premiums now, pays claims much later
- Pension plan: promises income for as long as you live
- Both sell a promise about an uncertain future
- Their job: price it, fund it, survive bad years

IN THE LESSON

- Picture a twenty five year old who buys a life policy and a company that promises to pay her family if she dies.
- She may live to ninety.
- The company must collect premiums, invest them, and still be able to pay forty or sixty years later.
- Now picture a pension plan.
- A worker spends thirty years earning and the employer promises an income for as long as the worker lives after retiring.
- Both institutions are paid today for a promise about an uncertain future.
- They must guess how long people live, how markets behave, and how big the claims will be.
- That guessing game is risk management, and it is what this lesson is about.

2 The three kinds of insurance company

- Life: pays on death, or while an annuitant lives
- Life liabilities run for decades
- Property-casualty: damage, liability; short policies
- Health: covers medical costs

IN THE LESSON

- Insurers fall into three broad groups.
- Life insurers pay when the insured dies or, with annuities, keep paying while the annuitant lives.
- Their liabilities therefore run for decades.
- Property and casualty insurers cover damage to property, and legal liability.
- Their policies usually last one year, though a liability claim can take years to settle.
- That delay matters later.
- Health insurers cover medical costs.
- Notice how the groups differ in time.
- A life insurer lives with long dated promises and a big pool of invested assets.
- A property and casualty insurer has short policies but bumpy, hard to predict claims.
- Keep this contrast in mind because the risks follow from it.

3 Match each business to its dominant risk

Know the pairing for each line of business

Line of business	Dominant risk
Life cover	Mortality: deaths come early
Annuities	Longevity: people live long
Property-casualty	Catastrophe and reserve risk
Health	Rising medical costs

IN THE LESSON

- Here is the matching exercise the course likes.
- For life cover, the dominant risk is mortality: people die sooner than the tables assumed, so death benefits arrive earlier or in greater number.
- For annuities, the dominant risk is longevity: people live longer than assumed, so payments continue for longer.
- For property and casualty insurance, the dominant risks are catastrophe losses and reserve risk.
- A hurricane or an earthquake can produce many claims at once.
- Reserve risk is the danger that the provisions set aside for claims already incurred prove too low.
- Health insurance faces rising medical costs, but the first three lines in the table are the ones to know cold.

4 The risks every insurer runs

- Underwriting: claims exceed the priced premiums
- Reserve: provisions for incurred claims prove too low
- Investment: credit, market, rate, duration gap
- Also liquidity, operational, reinsurer credit

IN THE LESSON

- Whatever the line, insurers face a common list of risks.
- Underwriting risk is the danger that claims exceed what the premiums were priced for, through mortality, longevity or catastrophe losses.
- Reserve risk is the danger that provisions for claims already incurred prove too low.
- Investment risk comes from credit, market and interest rate moves, and from a mismatch between the duration of assets and liabilities.
- Insurers also face liquidity risk, when cash is needed faster than assets can be sold, and operational risk, from failed processes and people.
- Finally there is credit risk on reinsurers, the firms that take over part of an insurer's risk.
- If a reinsurer fails, the insurer is left holding the claim.

5 Mortality tables: counting who survives

- Table gives q (death chance) or l (survivors)
- Follow 1,000 people: the number alive falls each year
- q = fall in survivors ÷ survivors at the start
- Survival chance = 1 − q

IN THE LESSON

- Now to pricing a life policy.
- The tool is the mortality table.
- For each age it records either the one year probability of dying, written q, or the number of survivors out of a starting group, written l.
- Imagine a group of one thousand sixty year olds followed through time.
- Each year some die, and the number alive falls.
- From survivor counts you can find the death probability for any year.
- It is the fall in survivors, divided by the number alive at the start of that year.
- The chance of reaching the start of a given year is the product of the survival chances of all the earlier years, and a survival chance is simply one minus q.

6 From survivors to a death probability

q = (l(x) − l(x+1)) ÷ l(x)

Death probability, q	Chance of dying within the year
Survivors at the age	Alive at age x
Survivors a year later	Still alive one year later

IN THE LESSON

- Here is the formula.
- The one year death probability at an age equals the number of survivors at that age, minus the number of survivors one year later, all divided by the survivors at that age.
- Read the top as the number who died during the year.
- The bottom is the number who started the year alive.
- So the formula is deaths divided by starters.
- Do not divide by the original group of one thousand, because we want the chance of dying among those who actually reached this age.
- That is a conditional probability.
- Dividing by the original group instead gives a different quantity, the chance of dying in that year seen from the very start, which we will need shortly.

7 Example 1: death probabilities from a table

Survivors: 1,000, 990, 975, 955 at ages 60 to 63 (illustration)

Deaths in year 1	1000 − 990	**10**
Death chance, age 60	10 ÷ 1000	**1.00%**
Death chance, age 61	(990 − 975) ÷ 990	**1.52%**
Death chance, age 62	(975 − 955) ÷ 975	**2.05%**

IN THE LESSON

- An illustration.
- A group of one thousand people aged sixty is followed.
- After one year nine hundred and ninety are alive, after two years nine hundred and seventy five, and after three years nine hundred and fifty five.
- In year one, ten people die: one thousand minus nine hundred and ninety.
- Divided by one thousand, the death probability is one per cent.
- In year two, nine hundred and ninety minus nine hundred and seventy five is fifteen deaths.
- Divided by nine hundred and ninety, that is one point five two per cent.
- In year three, nine hundred and seventy five minus nine hundred and fifty five is twenty deaths.
- Divided by nine hundred and seventy five, that is two point zero five per cent.

8 Example 2: alive at the start, dying in year n

Same table: chance alive at start, chance of dying in the year

Alive at start, year 2	1 − 1.00%	**99.0%**
Alive at start, year 3	99.0% × (1 − 1.52%)	**97.5%**
Dying in year 2	99.0% × 1.52%	**1.50%**
Dying in year 3	97.5% × 2.05%	**2.00%**

IN THE LESSON

- Now two chances we need for pricing.
- The chance of being alive at the start of year n is the product of earlier survival chances.
- At the start of year one it is certain.
- At the start of year two it is one minus one per cent, which is ninety nine per cent.
- At the start of year three it is ninety nine per cent times one minus one point five two per cent, which is ninety seven point five per cent.
- The chance of dying in year n is the chance of being alive at the start, times that year's death probability.
- In year two it is ninety nine per cent times one point five two per cent, which is one point five per cent.
- In year three, ninety seven point five per cent times two point zero five per cent gives two per cent.

9 The pure premium

P = B × Σ(Pr(death in t) × v^t) ÷ Σ(Pr(alive at start of t) × v^{t−1})

Pure premium	Level premium, paid while alive
Benefit paid	Paid at end of year of death
Chance of death in year	Chance of dying in year t
Chance alive at start	Chance alive at start of year t
Discount factor	v = 1 ÷ (1 + interest rate)

IN THE LESSON

- Now the price.
- Premiums are paid at the start of each year, but only while the insured is alive.
- The benefit is paid at the end of the year of death.
- The pure premium is the level amount that makes the present value of expected premiums equal to the present value of expected benefits.
- Solve for it.
- The premium equals the benefit, times the sum over each year of the chance of dying in that year multiplied by the discount factor for that many years, divided by the sum over each year of the chance of being alive at the start multiplied by the discount factor for one year fewer.
- The discount factor is one divided by one plus the interest rate.

10 Example 3: pricing a three-year term policy

Benefit $100,000, interest 5%, table from Example 1 (illustration)

PV of expected benefits	100,000 × 0.040406	**$4,041**
PV of premiums per $1	1 + 0.943 + 0.884	**2.827**
Pure premium	4,041 ÷ 2.827	**$1,429**
With 20% loading	1,429 × 1.20	**$1,715**

IN THE LESSON

- Take a three year policy on our sixty year old with a benefit of one hundred thousand dollars and an interest rate of five per cent.
- First, the present value of expected benefits.
- Weight each year's death chance by its discount factor: one per cent over one point zero five, plus one point five per cent over one point zero five squared, plus two per cent over one point zero five cubed.
- Times one hundred thousand, that is about four thousand and forty one dollars.
- Second, the expected number of premiums, discounted: one, plus point nine nine over one point zero five, plus point nine seven five over one point zero five squared.
- That is two point eight two seven.
- Divide: the pure premium is about one thousand four hundred and twenty nine dollars.
- A twenty per cent loading for expenses and profit lifts it to about one thousand seven hundred and fifteen.

11 Mortality risk and longevity risk

- Mortality risk: deaths sooner than assumed
- Hurts life insurers; typical scenario is a pandemic
- Longevity risk: people live longer than assumed
- Hurts pension plans and annuity writers

IN THE LESSON

- Both words concern the tables, but they point in opposite directions.
- Mortality risk is the risk that people die sooner than the tables assumed.
- It hurts a life insurer, because death benefits are paid earlier or in greater number.
- The typical scenario is a pandemic.
- Longevity risk is the opposite: people live longer than assumed.
- It hurts whoever pays while the person lives, namely pension plans and annuity writers, because they must keep paying.
- The typical scenario is steady medical improvement.
- Because the two move in opposite directions, a firm that writes both life cover and annuities enjoys a partial natural hedge.
- When people die early, the annuity book gains while the life book loses, and the reverse.

12 Ways to hedge each risk

Different risks, different tools

Risk or idea	Tools
Mortality risk	Reinsurance, mortality bonds
Longevity risk	Longevity bonds and swaps
Natural hedge	Write life cover and annuities
Index hedges	Leave basis risk

IN THE LESSON

- How can each risk be hedged?
- For mortality risk, an insurer can buy reinsurance, passing part of the death benefits to another firm.
- It can also use catastrophe mortality bonds, whose principal is cut if a mortality index spikes.
- Investors who buy them lose principal in a pandemic, and that loss pays the insurer's claims.
- For longevity risk, there are longevity bonds, whose coupons rise with the number of survivors.
- There are also longevity swaps, in which the hedger pays fixed amounts and receives amounts linked to actual survival.
- Finally, writing both types of business gives the natural hedge.
- One warning: index based hedges leave basis risk, because the index may not match the hedger's own group.

13 Example 4: a longevity swap in action

Expected pensions $100m; actual $106m (illustration)

Pensions actually paid	longevity above assumed	**−$106m**
Swap: receive actual	linked to survival	**+$106m**
Swap: pay fixed	agreed up front	**−$100m**
Net cash flow of the plan	−106 + 106 − 100	**−$100m**

IN THE LESSON

- A pension plan expects to pay one hundred million dollars of pensions this year.
- It enters a longevity swap.
- The plan pays the fixed amount of one hundred million and receives the amount linked to actual survival.
- Suppose people live longer than assumed, so pensions actually paid are one hundred and six million.
- The swap pays the plan the actual amount, one hundred and six million, and the plan pays away the fixed one hundred million.
- Now add it up.
- The plan pays pensions of one hundred and six million, receives one hundred and six from the swap, and pays one hundred under the swap.
- Its net cost is one hundred million, exactly as planned.
- The extra longevity cost has been passed to the swap counterparty.

14 Two ways to promise a pension

Hybrids such as cash balance plans sit between the two

Feature	DB | DC
The promise	Pension | Contribution
Investment risk	Sponsor | Member
Longevity risk	Sponsor | Member
Funding shortfall	Sponsor | None (member gets pot)
Portability	Hard | Easy

IN THE LESSON

- Now to the pension plans themselves.
- In a defined benefit plan the employer promises a pension fixed by a formula.
- The sponsor, which means the employer, bears the investment risk, the longevity risk and any funding shortfall.
- In a defined contribution plan the employer pays only an agreed contribution into an individual account, and the employee receives whatever the account grows to.
- So the employee bears the investment risk and the risk of outliving the savings.
- Defined contribution accounts are also easily portable when a worker changes job.
- Hybrid designs, such as cash balance plans, sit between the two.
- The key point is who carries which risk: the sponsor in defined benefit, the member in defined contribution.

15 The defined benefit pension formula

Pension = years of service × accrual rate × final salary

Pension	Annual pension, paid for life
Years of service	Years worked for the employer
Accrual rate	Fraction of salary earned per year
Final salary	Salary at retirement (or average)

IN THE LESSON

- Here is the typical defined benefit formula.
- The annual pension equals the years of service, multiplied by an accrual rate, multiplied by the final salary.
- The accrual rate is the fraction of salary earned as pension for each year worked.
- A worker with more years, or a higher final salary, receives a bigger pension.
- Some plans use average salary over the last several years or the whole career, instead of final salary.
- That changes the answer, because average salary is usually lower than the last salary, and it makes the plan cheaper for the sponsor.
- Notice what the formula does not mention: how the plan's investments performed.
- The sponsor must pay the formula amount whatever happens.

16 Example 5: a defined benefit pension

Plan formula: 30 years, 1.5% accrual, final salary $60,000 (illustration)

Years of service	worked	**30**
Accrual rate	per year of service	**1.5%**
Final salary	at retirement	**$60,000**
Pension, final salary	30 × 1.5% × 60,000	**$27,000**
Pension, average $48,000	30 × 1.5% × 48,000	**$21,600**

IN THE LESSON

- An illustration.
- A worker serves thirty years.
- The accrual rate is one point five per cent for each year.
- The final salary is sixty thousand dollars.
- The pension is thirty times one point five per cent times sixty thousand, which is twenty seven thousand dollars a year.
- Thirty times one point five per cent is forty five per cent, so the worker receives forty five per cent of final salary.
- Now suppose the plan uses average salary instead, and the average over the career was forty eight thousand dollars.
- The pension becomes forty five per cent of forty eight thousand, which is twenty one thousand six hundred dollars a year.
- The sponsor owes whichever the formula gives, whether or not the investments have done well.

17 Example 6: the defined contribution account

Contribution $10,000 a year for 10 years (illustration)

Employer pays in	10,000 × 10 years	**$100,000**
Balance if account earns 4%	annuity growth	**$120,061**
Balance if account earns 8%	annuity growth	**$144,866**
Gap borne by the member	144,866 − 120,061	**$24,805**

IN THE LESSON

- Now the member's side.
- An employer pays ten thousand dollars into the member's account at the end of each year for ten years.
- The employer's obligation ends there.
- If the account earns four per cent a year, the balance after ten years is about one hundred and twenty thousand dollars.
- If it earns eight per cent, it is about one hundred and forty five thousand.
- The gap is about twenty five thousand dollars, and it falls on the employee, not the employer.
- The employer paid the same amount in both cases, so the employer's cost did not change.
- This is what we mean by saying the member bears the investment risk.
- The member also bears the risk of outliving the savings, since a fixed pot may run out.

18 Example 7: a lower discount rate

Promise: $1,000,000 in 20 years; plan assets $400,000 (illustration)

Liability at 5%	1,000,000 ÷ 1.05^20	**$376,889**
Surplus at 5%	400,000 − 376,889	**+$23,111**
Liability at 4%	1,000,000 ÷ 1.04^20	**$456,387**
Result at 4%	400,000 − 456,387	**−$56,387**

IN THE LESSON

- Back to defined benefit plans, and to how the liability is measured.
- It is the present value of the promised payments, so it depends on the discount rate.
- Suppose the plan owes one million dollars in twenty years.
- Discounted at five per cent, the present value is about three hundred and seventy seven thousand dollars.
- The plan holds assets of four hundred thousand, so it is funded, with a surplus of about twenty three thousand.
- Now the discount rate falls to four per cent.
- The present value rises to about four hundred and fifty six thousand.
- The same assets leave a shortfall of about fifty six thousand.
- Nothing about the promise changed, yet a lower discount rate turned a funded plan into an underfunded one.

19 Life insurance policies, part one

Four basic contracts

Policy	Key feature
Term life	Pays only if death in the term
Whole life	Lifelong, level premium, cash
Endowment	Pays on death or on survival
Annuity	Pays while the holder lives

IN THE LESSON

- Now the kinds of life policy.
- Term life pays only if death occurs within a stated term.
- It has no savings element, and it is the cheapest cover.
- Whole life covers the insured for life, with level premiums.
- Early premiums exceed the cost of cover, which builds a cash value.
- Because payment is certain, it costs more than term.
- Endowment pays on death within the term, or a lump sum if the insured survives to the end.
- Annuities are different again: they pay for as long as the holder lives.
- Notice that an annuity is the mirror image of life cover.
- It protects against living too long, not dying too soon.

20 Life insurance policies, part two

Flexible and group designs

Policy	Key feature
Variable life	Cash in funds; holder bears risk
Universal life	Flexible; interest credited
Variable universal	Both flexibilities combined
Group life	Employees, no individual exam

IN THE LESSON

- Now the flexible designs.
- Variable life lets the policyholder direct the cash value into investment funds, and bear the investment result.
- Universal life allows flexible premiums and a flexible death benefit, with interest credited by the insurer.
- The insurer, not the policyholder, carries the investment performance.
- Variable universal life combines both flexibilities, so the holder chooses the funds and the premiums.
- Finally, group life covers employees under one contract, usually without individual medical underwriting, since the whole workforce is covered together.
- Notice the pattern: in the variable designs the policyholder takes the investment risk, while in plain universal life the insurer credits interest.

21 Exercise: match the need to the contract

Each need points to one contract

Cheapest cover for 20 years	no savings	**Term life**
Cover for life, cash value	level premiums	**Whole life**
Lump sum if alive at the end	or death in the term	**Endowment**
Income as long as I live	pays while alive	**Annuity**
Flexible premium and benefit	interest credited	**Universal life**

IN THE LESSON

- The course usually describes a need and asks for the matching contract.
- Practice.
- A young family wants the cheapest cover for the next twenty years, with no savings element.
- That is term life.
- Someone wants cover for their whole life, with level premiums that build a cash value.
- That is whole life.
- A person wants a lump sum if they survive to the end of the term, or a payment to their family if they die before.
- That is an endowment.
- A retiree wants income for as long as they live.
- That is an annuity.
- And someone wants to vary premiums and death benefit over the years, with the insurer crediting interest.
- That is universal life.

22 Four ratios for a property-casualty insurer

Combined = Loss ratio + Expense ratio
Operating = Combined − Investment income ratio

Loss ratio	Claims losses ÷ premiums
Expense ratio	Expenses ÷ premiums
Combined ratio	Loss ratio + expense ratio
Investment income ratio	Investment income ÷ premiums
Operating ratio	Combined − investment ratio

IN THE LESSON

- Now to judging a property and casualty insurer.
- Four ratios do the job, each expressed as a percentage of premiums.
- The loss ratio is claims losses divided by premiums.
- The expense ratio is operating and acquisition expenses divided by premiums.
- The combined ratio is the loss ratio plus the expense ratio.
- Some versions also add policyholder dividends.
- A combined ratio above one hundred per cent means an underwriting loss, before any investment income.
- The operating ratio is the combined ratio minus the investment income ratio, where the investment income ratio is investment income as a percentage of premiums.
- Subtract investment income to reach the operating ratio, never the combined ratio.

23 Example 8: computing the four ratios

Premiums $100m, losses $68m, expenses $30m, investment $7m (illustration)

Loss ratio	68 ÷ 100	**68%**
Expense ratio	30 ÷ 100	**30%**
Combined ratio	68% + 30%	**98%**
Investment income ratio	7 ÷ 100	**7%**
Operating ratio	98% − 7%	**91%**

IN THE LESSON

- An illustration.
- An insurer earns premiums of one hundred million dollars.
- Claims losses are sixty eight million, and expenses are thirty million.
- Investment income is seven million.
- The loss ratio is sixty eight divided by one hundred, which is sixty eight per cent.
- The expense ratio is thirty divided by one hundred, thirty per cent.
- The combined ratio is sixty eight plus thirty, ninety eight per cent, so there is a small underwriting profit.
- The investment income ratio is seven divided by one hundred, seven per cent.
- The operating ratio is ninety eight minus seven, which is ninety one per cent.
- Lower is better for the loss, expense, combined and operating ratios, while a higher investment income ratio is better.

24 Example 9: underwriting loss, overall profit

Premiums $100m, losses $72m, expenses $34m, investment $9m (illustration)

Combined ratio	(72 + 34) ÷ 100	**106%**
Underwriting result	100 − 72 − 34	**−$6m**
Operating ratio	106% − 9%	**97%**
Profit overall	−6 + 9	**+$3m**
If premiums fall to $80m	(72 + 34) ÷ 80	**132.5%**

IN THE LESSON

- Now a harder case.
- Premiums are one hundred million, losses seventy two million, expenses thirty four million, and investment income nine million.
- The combined ratio is seventy two plus thirty four over one hundred, which is one hundred and six per cent.
- Underwriting alone loses six million.
- But the operating ratio is one hundred and six minus nine, ninety seven per cent, and the insurer makes three million overall, because investment income more than covers the underwriting loss.
- Now the trap.
- If premiums fall to eighty million while claims and fixed expenses stay the same, the combined ratio becomes one hundred and six divided by eighty, which is one hundred and thirty two point five per cent.
- Premiums are the denominator, so the loss ratio and the expense ratio both rise, and with them the combined ratio.

25 Moral hazard and adverse selection

- Moral hazard (after signing): less care, bigger claims
- Example: careless parking because theft is covered
- Adverse selection (before signing): riskiest buy most
- Example: unhealthy applicants seek big cover

IN THE LESSON

- Insurers face two information problems, and the secret is the timing.
- Moral hazard arises after the contract is signed.
- Once insured, the policyholder takes less care or exaggerates claims, for example a driver who parks carelessly because theft is covered.
- Adverse selection arises before the contract.
- People who know they are riskier are the most eager to buy, for example unhealthy applicants seeking generous health cover.
- If the insurer charges an average price, the good risks find it too dear and leave, so the pool worsens.
- Remember: moral hazard is behavior after cover, adverse selection is who buys.
- The first is about hidden action, the second about hidden information.

26 Example 10: adverse selection in numbers

Equal numbers of two risk types (illustration)

Low-risk expected claim	half of buyers	**$100**
High-risk expected claim	half of buyers	**$300**
Average price charged	(100 + 300) ÷ 2	**$200**
If low risks leave, claims	only high risks stay	**$300**
Price must rise to	the new average	**$300**

IN THE LESSON

- Let's watch the pool worsen.
- An insurer sells the same cover to two groups, in equal numbers.
- Low risk people have an expected claim of one hundred dollars.
- High risk people have an expected claim of three hundred.
- The insurer cannot tell them apart and charges the average: one hundred plus three hundred, divided by two, which is two hundred dollars.
- For a low risk buyer, two hundred is twice the expected claim, so many leave.
- If all of them leave, only high risk buyers remain, and the average claim is three hundred dollars.
- The insurer must now raise the price to three hundred, and the pool is entirely the bad risks.
- That downward path is the problem of adverse selection.

27 Counter moral hazard or adverse selection

Loss sharing after cover; screening before cover

Tool	Aimed at
Deductible, coinsurance	Moral hazard: loss sharing
Limits, exclusions	Moral hazard: caps the cover
No-claims bonus	Moral hazard: rewards care
Underwriting, exams, forms	Adverse selection: screening
Risk-based price, waiting period	Adverse selection

IN THE LESSON

- Insurers have different tools for the two problems, and the labels must not be swapped.
- Against moral hazard they use deductibles, coinsurance, policy limits, exclusions and no claims bonuses, so that the insured keeps some of the loss and keeps taking care.
- A deductible is a loss sharing tool aimed at behavior after cover.
- Against adverse selection they use underwriting, medical exams, questionnaires, risk based premiums and waiting periods.
- A medical exam is a screening tool aimed at who buys.
- Risk based premiums make the price fit the person, so good risks are not driven away.
- Waiting periods stop people buying only when a claim is near.

28 Example 11: a deductible and coinsurance

Loss $10,000; deductible $1,000; insurer pays 80% above it (illustration)

Loss	suffered by the insured	**$10,000**
After the deductible	10,000 − 1,000	**$9,000**
Insurer pays 80%	80% × 9,000	**$7,200**
Policyholder bears	1,000 + 20% × 9,000	**$2,800**

IN THE LESSON

- Here is the loss sharing tool at work.
- A policy has a deductible of one thousand dollars, and the insurer pays eighty per cent of the loss above it.
- The insured suffers a loss of ten thousand dollars.
- First the deductible: ten thousand minus one thousand leaves nine thousand dollars.
- The insurer pays eighty per cent of nine thousand, which is seven thousand two hundred dollars.
- The policyholder keeps the deductible of one thousand plus twenty per cent of nine thousand, which is one thousand eight hundred.
- That totals two thousand eight hundred dollars.
- Because the insured bears real money from every loss, there is less reason to be careless or to exaggerate.
- That is exactly the aim.

29 Capital: what an insurer must hold

- Life: rates, credit, duration gap, mortality
- Property-casualty: catastrophe, reserve, pricing
- Solvency II: one-year 99.5% value at risk
- Reinsurance: less capital, but counterparty risk

IN THE LESSON

- Why do insurers hold capital?
- So that policyholder claims can still be paid after a bad year.
- A life insurer holds long dated liabilities against a large asset portfolio.
- Its capital is sensitive to interest rates, credit losses and the asset liability duration gap, as well as to mortality and longevity.
- A property and casualty insurer has shorter policies but volatile, partly correlated claims.
- Its capital is driven by catastrophe risk, reserve risk and pricing risk.
- Modern regimes set capital with a confidence level.
- In Europe, Solvency Two defines the solvency capital requirement as a one year value at risk at the ninety nine point five per cent level.
- Reinsurance cuts underwriting capital but adds counterparty credit risk, which is also charged.

30 Example 12: economic capital and correlation

Loss quantile $180m, expected loss $50m; modules $100m and $60m (illustration)

Loss at 99.5% level	one-year quantile	**$180m**
Expected loss	the average year	**$50m**
Economic capital	180 − 50	**$130m**
Simple sum of 100 and 60	no diversification	**$160m**
Combined, correlation 0.5	$\sqrt{(100^2+60^2+2\times.5\times100\times60)}$	**$140m**

IN THE LESSON

- Economic capital is the loss at the chosen confidence level, minus the expected loss.
- Suppose an insurer's loss at the ninety nine point five per cent level is one hundred and eighty million dollars, and its expected loss is fifty million.
- Capital is one hundred and eighty minus fifty, which is one hundred and thirty million.
- In a separate example, now combine risk modules.
- Underwriting risk needs one hundred million and market risk needs sixty million.
- The simple sum is one hundred and sixty million.
- But with a correlation of point five, the combined figure is the square root of one hundred squared plus sixty squared plus two times point five times one hundred times sixty.
- That is the square root of nineteen thousand six hundred, which is one hundred and forty million.
- Correlation below one means total capital is below the simple sum.

31 Insurers compared with banks

Banks: premium-funded and federal. Insurers: post-failure levy and state-based

Topic	Banks | Insurers
Guaranty system	Prefunded | Levy after failure
US regulator	Federal | State by state
Capital covers	Basel risks | + underwriting
Confidence level	99.9% | 99.5%
Run risk	High | Lower

IN THE LESSON

- Finally, compare insurers with banks.
- Both are regulated for solvency, but the systems differ.
- In the United States, banks face federal regulation and deposit insurance, funded by premiums that banks pay in advance.
- Insurers are regulated mainly state by state.
- Policyholders are protected by state guaranty associations, which in most states levy the surviving insurers after a failure.
- Bank capital under Basel covers credit, market and operational risk, with liquidity standards added.
- The credit risk internal ratings approach uses a ninety nine point nine per cent confidence level.
- Insurance regimes such as Solvency Two use ninety nine point five per cent and add underwriting risk, which banks do not have.
- Insurers also face less run risk, because policies cannot be withdrawn on demand like deposits.

32 Four mistakes to avoid

- Premiums are not certain: weight by survival chances
- Mortality is early death; longevity is long life
- Investment income comes off combined to give operating
- Deductible: moral hazard; exam: adverse selection

IN THE LESSON

- Four mistakes catch learners again and again.
- First, treating the premium stream as certain.
- Premiums are paid only while the insured is alive, so weight them by survival chances.
- Second, mixing up mortality and longevity.
- Early death hurts the life insurer; long life hurts the pension plan and annuity writer.
- Third, getting the investment income direction wrong.
- You subtract it from the combined ratio to reach the operating ratio, and you never subtract it to reach the combined ratio.
- Fourth, swapping the labels.
- A deductible tackles moral hazard after cover; a medical exam tackles adverse selection before cover.

33 Recap: the whole module on one page

- Risks: underwriting, reserve, investment, liquidity
- Premium: PV of premiums = PV of benefits
- Sponsor bears DB risk; member bears DC risk
- Combined = loss + expense; operating = combined − inv.
- Capital = loss quantile − expected loss; banks differ

IN THE LESSON

- Let us recap.
- Insurers are life, property and casualty, or health, and they run underwriting, reserve, investment, liquidity, operational and reinsurer credit risk.
- A mortality table gives death chances from survivor counts, and the pure premium equates the present value of expected premiums to that of expected benefits.
- Mortality risk is early death, longevity risk is long life, and each has its hedges.
- In defined benefit plans the sponsor carries the risk, and in defined contribution plans the member does.
- We met the kinds of life policy, the four ratios, moral hazard and adverse selection and their cures, capital set at a confidence level, and how insurers differ from banks.

34 Quiz time

1. Loss 65%, expense 31%, investment 8%: ratios?
   Answer: Combined 96%; operating 96 − 8 = 88%
2. l = 1000, 980, 950: death chance in year 2?
   Answer: (980 − 950) ÷ 980 = 3.06%
3. Longevity swap: whose risk, what flows?
   Answer: The hedger's (plan or annuity writer); pays fixed, gets actual

IN THE LESSON

- Time to test yourself.
- Question one.
- A policy has a loss ratio of sixty five per cent, an expense ratio of thirty one per cent and an investment income ratio of eight per cent.
- What are the combined and operating ratios?
- Question two.
- A group of one thousand has nine hundred and eighty survivors after one year and nine hundred and fifty after two.
- What is the death probability in year two?
- Question three.
- A longevity swap hedges whose risk, and what does the hedger pay and receive?
- Pause, think about each, and then check the answers on the board.