Insurance Financial Modeling with Claude

النمذجة المالية لقطاع التأمين

Level: Advanced

Learning Objectives

- Understand the fundamental economics of insurance: premium collection, risk pooling, claims payment, and investment income
- Distinguish between Property & Casualty (P&C/General) insurance and Life & Health insurance modeling approaches
- Build a comprehensive insurance financial model using Claude, covering underwriting, reserving, and investment portfolios
- Master loss ratio analysis and combined ratio decomposition for assessing underwriting profitability
- Construct reserve adequacy models using the chain-ladder method (loss development triangles)
- Calculate and interpret solvency metrics under Solvency II (capital adequacy) and IFRS 17 (liability measurement)
- Model investment portfolio returns and asset-liability matching for insurance companies
- Analyze reinsurance structures and their impact on net retention, volatility, and capital requirements
- Build catastrophe (CAT) loss models and assess their impact on earnings and capital
- Use Claude to perform embedded value analysis for life insurance portfolios
- Apply claims frequency and severity analysis to price insurance products
- Benchmark insurance companies using industry-specific metrics and peer comparison frameworks

14.1 Industry Overview: Insurance

The insurance industry operates on a fundamentally different business model from most other financial services. Insurers collect premiums upfront in exchange for a promise to pay future claims — creating an inverted production cycle where revenue is received before costs are incurred. This unique characteristic creates both opportunities (investment float) and challenges (uncertain liabilities that may not crystallize for years or decades).

Insurance financial modeling requires specialized knowledge of actuarial concepts, regulatory frameworks, and industry-specific accounting standards. The two major segments — Property & Casualty (P&C, also called General or Non-Life insurance) and Life & Health insurance — have fundamentally different risk profiles, liability durations, and modeling approaches.

Key Financial Characteristics

- Inverted production cycle: Premiums collected before claims paid, creating investable float
- Long-tail liabilities: Some claims (especially liability, workers compensation) take years to fully develop and settle
- Underwriting cycle: P&C markets alternate between hard markets (high prices, tight capacity) and soft markets (low prices, excess capacity) in 5-10 year cycles
- Investment income as profit driver: Many insurers operate at combined ratios near or above 100%, relying on investment income for profitability
- Catastrophe exposure: Natural and man-made disasters create lumpy, unpredictable losses
- Regulatory solvency requirements: Solvency II (Europe), Risk-Based Capital (US), and local frameworks mandate minimum capital levels
- IFRS 17 transformation: New accounting standard fundamentally changes how insurance contracts are measured and reported

- Reinsurance as capital management tool: Ceding risk to reinsurers reduces volatility and capital requirements

Revenue Drivers

Insurance revenue consists of two primary streams:

1. Underwriting Income

Gross Written Premiums (GWP) represent the total premiums written during a period. After deducting premiums ceded to reinsurers, the result is Net Written Premiums (NWP). Earned premiums represent the portion of NWP attributable to the coverage period that has elapsed. Underwriting income = Earned premiums - Incurred claims - Operating expenses. The combined ratio (claims ratio + expense ratio) measures underwriting profitability: below 100% indicates an underwriting profit.

2. Investment Income

Insurers invest the float (premiums collected but not yet paid as claims) in bonds, equities, real estate, and alternative assets. For P&C insurers, the investment portfolio is typically 2-4x annual premiums. For life insurers, the investment portfolio can be 8-15x annual premiums due to longer liability durations. Investment income includes interest, dividends, rental income, and realized/unrealized gains.

Cost Structure

- Claims/losses (55-75% of earned premiums for P&C) — the largest and most variable cost item
- Loss adjustment expenses (LAE) (5-10%) — costs of investigating and settling claims
- Acquisition costs (15-25%) — commissions to agents/brokers, marketing, underwriting expenses
- Administrative expenses (8-15%) — operations, technology, regulatory compliance
- Reinsurance costs (variable) — premiums ceded to reinsurers for risk transfer

Business Models

Segment	Products	Key Metrics	Liability Duration
P&C — Personal Lines	Auto, Home, Personal liability	Loss ratio, Renewal rate	Short (1-3 years)
P&C — Commercial Lines	Property, Liability, Workers comp	Combined ratio, Rate adequacy	Medium (2-10 years)
P&C — Specialty/Reinsurance	CAT, Marine, Aviation, Cyber	Return period, PML	Variable
Life — Protection	Term life, Whole life, Disability	Mortality experience, Lapse rate	Long (10-50+ years)
Life — Savings/Investment	Annuities, Unit-linked, Pensions	AUM growth, Persistency	Very long (20-60 years)
Health	Medical, Critical illness, PMI	Medical loss ratio, Claims frequency	Short (1 year)

Key Performance Indicators (KPIs)

1. Loss Ratio

Loss Ratio = Incurred Claims / Earned Premiums

The loss ratio measures the proportion of premiums consumed by claims. For P&C insurers, a loss ratio of 55-75% is typical for profitable lines. Loss ratios above 75% generally indicate underpricing or adverse loss development. The loss ratio can be decomposed into frequency (number of claims per policy) and severity (average cost per claim).

2. Combined Ratio

Combined Ratio = Loss Ratio + Expense Ratio

The combined ratio is the definitive measure of underwriting profitability. A combined ratio below 100% means the insurer is making an underwriting profit; above 100% means an underwriting loss. The expense ratio = (acquisition costs + administrative expenses) / earned premiums. Top-quartile P&C insurers achieve combined ratios of 90-95%.

3. Expense Ratio

Expense Ratio = (Acquisition Costs + Administrative Expenses) / Earned Premiums

The expense ratio measures operational efficiency. Direct writers (no intermediary) typically have lower acquisition costs but higher marketing spend. Broker-distributed insurers have higher commission costs (15-25%) but lower customer acquisition costs. Administrative expense ratios of 8-12% are considered efficient.

4. Solvency Ratio

Solvency Ratio = Own Funds / Solvency Capital Requirement (SCR)

Under Solvency II, insurers must hold capital (Own Funds) at least equal to the SCR, which represents the capital needed to absorb losses over a 1-year period at a 99.5% confidence level. A solvency ratio of 150-200% is considered comfortable. Below 120% triggers regulatory intervention.

5. Investment Yield

Investment Yield = Net Investment Income / Average Invested Assets

Investment yield measures the return generated on the insurer's investment portfolio. Typical ranges: 2-4% for conservative P&C portfolios (predominantly bonds), 3-6% for life insurer portfolios (which can include more alternatives and equities). Unrealized gains/losses on the portfolio are also important for solvency assessment.

6. Claims Frequency and Severity

Claims Frequency = Number of Claims / Number of Policies

Claims Severity = Total Incurred Claims / Number of Claims

Decomposing the loss ratio into frequency and severity components provides insight into underlying trends. Rising severity with stable frequency may indicate inflation; rising frequency may indicate adverse selection or environmental changes (e.g., climate-related events).

7. Renewal/Retention Rate

Renewal Rate = Policies Renewed / Policies Eligible for Renewal

High renewal rates (85-95%) indicate customer satisfaction and reduce acquisition costs. Each percentage point of improvement in retention has a significant impact on lifetime profitability, as renewal business typically has lower loss ratios than new business (adverse selection in new policies).

14.2 Deep-Dive Model: Insurance Financial Model Walkthrough

In this section, we build a comprehensive P&C insurance financial model using Claude. The model covers premium projection, loss ratio analysis, reserve development, investment portfolio, and solvency assessment.

Module 1: Premium Volume and Growth Projection

Premium projection is the starting point for any insurance financial model. Growth is driven by rate changes (pricing), exposure growth (volume of insured risks), and retention rates.

Prompt:

Build a 5-year premium projection for [Insurance Company] with current GWP of $[X]B across these lines: Auto $[A]M, Property $[B]M, Casualty/Liability $[C]M, Workers Compensation $[D]M, Specialty $[E]M. Assume rate increases of [F]% (auto), [G]% (property), [H]% (casualty) per year, exposure growth of [I]% across all lines, retention

rate of [J]%. Calculate GWP, NWP (reinsurance cession rate [K]%), and earned premiums for each year and line of business.

Line of Business	Year 1 GWP	Year 3 GWP	Year 5 GWP	CAGR
Auto	$2,500M	$2,810M	$3,158M	6.0%
Property	$1,800M	$2,117M	$2,489M	8.4%
Casualty/Liability	$1,200M	$1,370M	$1,564M	6.8%
Workers Comp	$800M	$873M	$952M	4.4%
Specialty	$700M	$798M	$910M	6.8%
Total GWP	$7,000M	$7,968M	$9,073M	6.7%
Reinsurance Ceded	($1,400M)	($1,594M)	($1,815M)	
Net Earned Premiums	$5,320M	$6,058M	$6,895M	6.7%

Module 2: Loss Ratio Analysis and Combined Ratio Decomposition

The combined ratio determines whether an insurer is profitable from its core underwriting operations. A thorough analysis requires decomposing the combined ratio by line of business and identifying trends in each component.

Prompt:

Analyze underwriting profitability for [Insurance Company]: Net earned premiums $[X]M, incurred claims $[Y]M (split: attritional claims $[A]M, large losses $[B]M, catastrophe losses $[C]M), acquisition costs $[D]M, administrative expenses $[E]M. Calculate: gross loss ratio, net loss ratio, expense ratio, combined ratio, and underwriting

result. Decompose by line of business and compare to 5-year historical averages. Identify the top-3 lines contributing most to underwriting profit/loss.

Component	Auto	Property	Casualty	Workers Comp	Total
Loss Ratio	68.5%	62.0%	71.2%	65.8%	66.8%
Attritional	58.0%	42.0%	55.0%	58.0%	52.8%
Large Losses	6.5%	8.0%	12.2%	5.8%	8.2%
CAT Losses	4.0%	12.0%	4.0%	2.0%	5.8%
Expense Ratio	28.5%	30.2%	32.5%	29.0%	29.8%
Combined Ratio	97.0%	92.2%	103.7%	94.8%	96.6%

Module 3: Reserve Adequacy — Chain-Ladder Method

Reserve adequacy is one of the most critical assessments in insurance financial modeling. The chain-ladder method (also called the loss development method) uses historical claims development patterns to project ultimate losses for each accident year.

The method works by analyzing a loss development triangle — a matrix showing cumulative paid (or incurred) claims for each accident year at successive development periods. Development factors are calculated for each period, and the most recent accident years are projected to ultimate using these factors.

Prompt:

Build a chain-ladder reserve analysis for [Insurance Company]. Provide the paid claims development triangle for accident years [AY1] through [AY5] with development periods

1 through 5 years. Calculate age-to-age development factors, selected factors (using weighted average), cumulative development factors, projected ultimate losses for each accident year, and IBNR (Incurred But Not Reported) reserves. Assess reserve adequacy by comparing carried reserves to actuarial estimate. Flag any accident years showing adverse or favorable development.

Example Loss Development Triangle (Cumulative Paid Claims, $M):

Accident Year	Dev Year 1	Dev Year 2	Dev Year 3	Dev Year 4	Dev Year 5
2021	1,200	1,680	1,890	1,950	1,970
2022	1,350	1,850	2,100	2,180	
2023	1,500	2,050	2,310		
2024	1,420	1,950			
2025	1,580				

Development Factor Calculation:

Period	1→2	2→3	3→4	4→5	To Ultimate
Weighted Avg Factor	1.377	1.129	1.035	1.010	
Cumulative Factor	1.624	1.179	1.045	1.010	1.000

Module 4: Investment Portfolio and Asset-Liability Matching

The investment portfolio is a critical profit driver for insurers, particularly those operating at combined ratios near 100%. The portfolio must be managed with two objectives: maximizing risk-adjusted returns while maintaining sufficient liquidity and duration matching with insurance liabilities.

Prompt:

Analyze the investment portfolio for [Insurance Company]: Total invested assets $[X]B, allocated as government bonds [A]%, corporate bonds [B]%, equities [C]%, real estate [D]%, alternatives [E]%, cash [F]%. Average duration of bond portfolio: [G] years. Average liability duration: [H] years. Calculate: investment yield, total return (including unrealized gains/losses), duration gap, and asset-liability mismatch. Model the impact of a 100bps rise in interest rates on portfolio value and solvency ratio. Recommend optimal asset allocation given the liability profile.

Asset Class	Allocation	Market Value ($B)	Yield	Duration
Government Bonds	35%	5.25	3.2%	5.5 yrs
Corporate Bonds	30%	4.50	4.1%	4.2 yrs
Equities	15%	2.25	2.5% (div)	N/A
Real Estate	8%	1.20	5.8%	N/A
Alternatives	7%	1.05	7.2%	N/A
Cash & Short-term	5%	0.75	4.0%	0.2 yrs
Total	100%	15.00	3.9%	3.2 yrs

Portfolio				

Module 5: Solvency II Capital Assessment

Solvency II is the European regulatory framework for insurance companies, built on three pillars: quantitative requirements (Pillar 1), governance and risk management (Pillar 2), and disclosure (Pillar 3). The key quantitative metrics are:

- Solvency Capital Requirement (SCR): Capital needed to absorb losses over 1 year at 99.5% confidence
- Minimum Capital Requirement (MCR): Absolute floor below which the insurer must cease operations
- Own Funds: Available capital classified into Tier 1, Tier 2, and Tier 3

The SCR can be calculated using the Standard Formula or an approved Internal Model. The Standard Formula aggregates capital charges across risk modules:

- Underwriting Risk (premium, reserve, catastrophe) — typically 40-55% of diversified SCR
- Market Risk (interest rate, equity, property, spread, currency) — typically 30-45%
- Counterparty Default Risk — typically 5-10%
- Operational Risk — typically 5-8%

Prompt:

Calculate Solvency II capital position for [Insurance Company]: Eligible Own Funds $[X]B (Tier 1: $[A]B, Tier 2: $[B]B, Tier 3: $[C]B or negligible). SCR components: Underwriting risk $[C]M, Market risk $[D]M, Counterparty risk $[E]M, Operational risk $[F]M, Diversification benefit ($[G]M). Calculate total SCR, solvency ratio, and excess capital. Assess sensitivity to: (1) 20% equity market decline, (2) 100bps interest rate rise, (3) 1-in-200 year CAT event, (4) 10% reserve strengthening. For each stress, show the impact on solvency ratio.

Module 6: Reinsurance Structure and Optimization

Reinsurance is a critical capital management tool that allows insurers to transfer risk, reduce earnings volatility, and optimize their capital position. Understanding reinsurance structures is essential for insurance financial modeling.

Common Reinsurance Structures:

- Quota Share: Proportional treaty where the reinsurer assumes a fixed percentage (e.g., 30%) of premiums and claims
- Surplus Treaty: Proportional treaty where the reinsurer assumes risk above the insurer's retention line
- Excess of Loss (XoL): Non-proportional treaty where the reinsurer pays claims above a retention (e.g., $5M xs $5M)
- Catastrophe XoL: Protects against accumulated losses from a single catastrophic event (e.g., $500M xs $100M)
- Stop Loss: Aggregate protection when total losses exceed a percentage of earned premiums

Prompt:

Analyze the reinsurance program for [Insurance Company]: GWP $[X]B, current reinsurance structure — Quota Share [A]% on Property, XoL $[B]M xs $[C]M per risk, CAT XoL $[D]M xs $[E]M per occurrence. Reinsurance cost: $[F]M. Calculate: cession ratio, net retention, reinsurance leverage, and the impact of reinsurance on combined ratio and solvency ratio. Model an alternative structure replacing the Quota Share with a higher XoL retention and calculate the impact on: (1) premium retention, (2) earnings volatility, (3) capital requirements, (4) ROE.

14.3 Quick Reference Prompts

Prompt 1: Combined Ratio Trend Analysis

Prompt:

Analyze 5-year combined ratio trends for [Insurance Company] by line of business. Provide: loss ratio (attritional + large + CAT), expense ratio (acquisition + admin), and combined ratio for each year and line. Identify: (1) lines with improving/deteriorating trends, (2) impact of catastrophe events on each year's results, (3) expense ratio efficiency gains, (4) rate adequacy assessment based on loss ratio trends. Calculate the underlying combined ratio excluding CAT and prior-year reserve development.

Prompt 2: Reserve Development Analysis

Prompt:

Analyze reserve development for [Insurance Company] over the past 5 calendar years. For each prior accident year, show: initial reserve estimate, current estimate, favorable/(adverse) development in dollars and percentage. Calculate the aggregate reserve release/strengthening as a percentage of opening reserves. Assess whether the company has a pattern of over- or under-reserving. Compare development patterns to industry benchmarks by line of business.

Prompt 3: Catastrophe Loss Modeling

Prompt:

Build a catastrophe loss model for [Insurance Company] with insured exposure of $[X]B. Model the following return periods: 1-in-10 year ($[A]M), 1-in-25 year ($[B]M), 1-in-50 year ($[C]M), 1-in-100 year ($[D]M), 1-in-250 year ($[E]M). Apply the reinsurance program: CAT XoL $[F]M xs $[G]M, with reinstatement. Calculate net CAT losses at each return period, Probable Maximum Loss (PML) as % of equity, and the impact on combined ratio and solvency ratio. Assess whether the current CAT budget of [H]% of earned premiums is adequate.

Prompt 4: Pricing Adequacy Assessment

Prompt:

Assess pricing adequacy for [Product Line] at [Insurance Company]. Data: earned premium $[X]M, target combined ratio [Y]%, current attritional loss ratio [Z]%, trend factor [A]% per annum, expense ratio [B]%, large loss load [C]%, CAT load [D]%. Calculate the technically required premium rate, compare to current pricing, and determine the rate change needed to achieve the target combined ratio. Model the impact of different loss trend assumptions (±2pp) on required rate changes.

Prompt 5: Investment Portfolio Optimization

Prompt:

Optimize the investment portfolio for [Insurance Company]: Total invested assets $[X]B, liability duration [Y] years, SCR for market risk $[Z]M. Current allocation: government bonds [A]%, corporate bonds [B]%, equities [C]%, alternatives [D]%. Model three alternative allocations: (1) Conservative — increase bonds, reduce equities; (2) Balanced — maintain current with duration extension; (3) Growth — increase alternatives and equities. For each, calculate: expected return, portfolio duration, duration gap, SCR impact, and solvency ratio change. Recommend optimal allocation given risk tolerance of [E] solvency ratio target.

Prompt 6: Peer Benchmarking

Prompt:

Perform peer benchmarking for [Insurance Company] against [Peer 1], [Peer 2], [Peer 3]. Compare across: (1) Underwriting — combined ratio by line, loss ratio trend, expense efficiency; (2) Reserving — reserve adequacy ratio, development pattern; (3) Investment — yield, asset allocation, duration management; (4) Capital — solvency ratio, ROE,

dividend capacity; (5) Growth — GWP growth, market share, new product development. Create a scorecard with quartile rankings and overall composite score.

Prompt 7: IFRS 17 Impact Analysis

Prompt:

Analyze IFRS 17 implementation impact for [Insurance Company]. Model the Building Blocks Approach (BBA) for long-duration contracts: Present Value of Future Cash Flows $[X]B, Risk Adjustment $[Y]M, Contractual Service Margin (CSM) $[Z]B. Calculate: insurance revenue recognition pattern over contract lifetime, CSM amortization schedule, and impact of experience variances on P&L. Compare IFRS 17 profit emergence pattern to the previous IFRS 4 basis. Quantify the impact on key metrics: ROE, combined ratio equivalent, and book value.

Prompt 8: Embedded Value for Life Insurance

Prompt:

Calculate Market Consistent Embedded Value (MCEV) for [Life Insurance Company]. Components: Net Asset Value $[X]B, Value of In-Force Business (VIF) $[Y]B. Decompose VIF into: present value of future profits $[A]B, time value of options & guarantees ($[B]M), cost of residual non-hedgeable risks ($[C]M), frictional costs ($[D]M). Calculate: MCEV per share, VIF multiple, new business value $[E]M, new business margin [F]%. Model sensitivity to: risk discount rate ±100bps, equity markets ±10%, lapse rates ±10%, mortality ±5%.

14.4 Insurance Financial Modeling Cheat Sheet

Core Insurance Formulas

Metric	Formula	Typical Range
Loss Ratio	Incurred Claims / Earned Premiums	55-75% (P&C)
Expense Ratio	(Acquisition + Admin) / Earned Premiums	25-35%
Combined Ratio	Loss Ratio + Expense Ratio	< 100% (profit)
Operating Ratio	Combined Ratio - Investment Income Ratio	< 90% (strong)
Investment Yield	Net Investment Income / Avg Invested Assets	2-4% (P&C), 3-6% (Life)
Solvency Ratio	Own Funds / SCR	> 150% (comfortable)
Reserve-to-Premium	Net Reserves / Net Earned Premiums	1.0-2.5x (P&C)
Premium-to-Surplus	NWP / Policyholder Surplus	< 2.0x (conservative)
Claims Frequency	Number of Claims / Number of Policies	Varies by line
Claims Severity	Total Claims / Number of Claims	Varies by line

Renewal Rate	Renewed Policies / Eligible Policies	85-95%
Cession Ratio	Reinsurance Ceded / GWP	15-30%
ROE	Net Income / Average Shareholders' Equity	10-15% (target)

P&C Insurance Income Statement Template

Line Item	Formula	Amount
Gross Written Premiums (GWP)		$X
Less: Reinsurance Ceded		($X)
Net Written Premiums (NWP)	GWP - Ceded	$X
Change in Unearned Premium Reserve		($X)
Net Earned Premiums (NEP)	NWP ± UPR change	$X
Incurred Claims (net)		($X)
Acquisition Costs		($X)
Administrative Expenses		($X)
Underwriting Result	NEP - Claims - Expenses	$X
Net Investment Income		$X
Realized Gains/(Losses)		$X
Operating Profit	UW Result + Investment	$X

Tax		($X)
Net Income		$X

P&C vs. Life Insurance Comparison

Dimension	P&C / General Insurance	Life Insurance
Contract Duration	1 year (renewable)	10-50+ years
Liability Type	Short-tail (mostly)	Long-tail
Key Risk	Catastrophe, frequency/severity	Mortality, longevity, lapse
Primary Metric	Combined ratio	Embedded value, VNB margin
Investment Duration	Short-medium (2-5 years)	Long (10-20+ years)
Accounting	Premium Allocation Approach	Building Blocks Approach (IFRS 17)
Reserve Method	Chain-ladder, Bornhuetter-Ferguson	Actuarial (mortality tables)
Pricing Cycle	Hard/soft market cycle	Relatively stable
Float Leverage	2-4x premiums	8-15x premiums

References

EIOPA. "Solvency II: Technical Specifications for the Preparatory Phase." European Insurance and Occupational Pensions Authority, 2014.

IFRS Foundation. "IFRS 17 Insurance Contracts." International Accounting Standards Board, 2017 (amended 2020, effective 1 January 2023).

Swiss Re Institute. "World Insurance: Sigma Report." Swiss Re, 2024.

Casualty Actuarial Society. "Estimating Unpaid Claims Using Basic Techniques." CAS, 2023.

AM Best. "Best's Credit Rating Methodology: Global Life and Non-Life Insurance." AM Best, 2024.

Guy Carpenter. "Global Property Catastrophe Rate-on-Line Index." Guy Carpenter, 2024.