Exam 7 High-Level Summaries

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Rising Fellow

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Table of Contents

Mack - Benktander

Credible Claims Reserves: The Benktander Method

Overview

The Mack – Benktander paper is a calculation-heavy paper. Most importantly, you need to be able to estimate Benktander reserves a number of different ways based on how the problem is written. Another key concept to remember is that the Benktander ultimate loss estimate is a credibility-weighting of the chain ladder and expected loss ultimates.

Benktander Method

The Benktander method can be calculated as a second iteration of the BF procedure or as a credibility-weighting of the Chain Ladder and Expected Loss ultimates (see the "Mack-Benktander – Benktander Method" recipe).

Benktander as a second iteration of the BF procedure

Iteration 1 – Bornhuetter-Ferguson:

$$\boxed{U_{BF} = C_k + q_k U_0} \qquad Ult_{BF} = Loss + (1 - \%Paid) \times Prem \times ELR$$

Iteration 2 – Benktander:

$$\boxed{U_{GB} = C_k + q_k U_{BF}} \qquad U_{GB} = Loss + (1 - \%Paid) \times Ult_{BF}$$

Benktander as a credibility-weighting of the Chain Ladder and Expected Loss Ultimates

Chain Ladder Ultimate:

$$\boxed{U_{CL} = \frac{C_k}{p_k}} \qquad Ult_{CL} = Loss \times CDF$$

Benktander:

$$\boxed{q_k = 1 - \frac{1}{CDF}}$$

$$\boxed{U_{GB} = \left(1 - q_k^2\right) U_{CL} + q_k^2 \times U_0} \qquad Ult_{GB} = \left[1 - \%Unpaid^2\right] \times Ult_{CL} + \%Unpaid^2 \times Prem \times ELR$$

Benktander as a credibility-weighting of the Chain Ladder and BF Reserves

$$\boxed{R_{GB} = \left(1 - q_k\right) R_{CL} + q_k \times R_{BF}} \qquad Resv_{GB} = \left[1 - \%Unpaid\right] \times Resv_{CL} + \%Unpaid \times Resv_{BF}$$

Advantages of the Benktander Method

- Outperforms the BF and Chain Ladder methods in many circumstances
- The MSE of the Benktander reserve is almost as small as that of the optimal credibility reserve

Iterated BF Method

The Benktander method is a second iteration of the BF procedure. This is how the iteration works:

1. Start with an ultimate loss estimate, $U^{(m)}$. For $U^{(0)}$, use the expected loss estimate.
2. Apply the BF procedure to get a new loss reserve estimate:

$$\boxed{R^{(m)} = q_k U^{(m)}} \qquad Resv^{(m)} = \%Unpaid \times Ult^{(m)}$$

3. Get a new ultimate loss estimate by adding the losses-to-date to the reserve. This is the starting ultimate for the next iteration:

$$\boxed{U^{(m+1)} = C_k + R^{(m)}} \qquad Ult^{(m+1)} = Loss_k + Resv^{(m)}$$

The ultimate loss estimate ($U^{(m)}$) can be rearranged as a credibility weighting of the Chain Ladder ultimate (U_{CL}) and expected loss ultimate (U_0). Also, the loss reserve estimate ($R^{(m)}$) can be rearranged as a credibility weighting of the Chain Ladder reserve (R_{CL}) and the BF reserve (R_{BF}):

$$\boxed{U^{(m)} = \left(1 - q_k^m\right) U_{CL} + q_k^m \times U_0} \qquad \boxed{R^{(m)} = \left(1 - q_k^m\right) R_{CL} + q_k^m \times R_{BF}}$$

m	Starting Ultimate ($U^{(m)}$)		New Reserve ($R^{(m)}$)
0	$U_0 = Prem \times ELR$	$\times \%Unpaid$	$R_{BF} = q_k U_0$
1	$U_{BF} = Loss + R_{BF}$ $U^{(1)} = \left(1 - q_k^1\right) U_{CL} + q_k^1 \times U_0$	+	$R_{GB} = q_k U_{BF}$ $R^{(1)} = \left(1 - q_k^1\right) R_{CL} + q_k^1 \times R_{BF}$
2	$U_{GB} = Loss + R_{GB}$ $U^{(2)} = \left(1 - q_k^2\right) U_{CL} + q_k^2 \times U_0$		$R^{(2)} = q_k U^{(2)}$ $R^{(2)} = \left(1 - q_k^2\right) R_{CL} + q_k^2 \times R_{BF}$
⋮	⋮		⋮
∞	$U^{(\infty)} = U_{CL}$		$R^{(\infty)} = R_{CL}$

As the number of iterations increases, the weight on the chain ladder method increases until it converges to the chain ladder method entirely (as $m \to \infty$).

Recipes for Calculation Problems

- Benktander Method

Hürlimann

Credible Loss Ratio Claims Reserves

Overview

The reserve estimate method in Hürlimann is a credibility-weighted method that's very similar to the Mack (2000) method. The key difference is that Hürlimann uses expected incremental loss ratios (m_k) to specify the payment pattern instead of using LDFs calculated directly from the losses.

Hürlimann uses two new reserving methods based on the loss ratio payout factors, p_i:

- Individual Loss Ratio Reserve (R^{ind}) – Similar to the chain ladder method
- Collective Loss Ratio Reserve (R^{coll}) – Similar to the Bornhuetter-Ferguson (BF) method

The key idea from Hürlimann is that R^{ind} and R^{coll} represent extremes of credibility on the actual loss experience and we can calculate a credibility-weighted estimate that minimizes the MSE of the reserve estimate.

Credible Loss Ratio Claims Reserve

Individual Loss Ratio Claims Reserve (R^{ind})

$$\boxed{R^{ind} = \frac{q_i \cdot Loss_i}{p_i}} \qquad R^{ind} = \frac{\%Unpaid_{AY} \cdot Loss_{AY}}{\%Paid_{AY}}$$

R^{ind} – 100% credibility on losses-to-date

Collective Loss Ratio Claims Reserve (R^{coll})

$$\boxed{R^{coll} = q_i \cdot Prem \cdot ELR} \qquad R^{coll} = \%Unpaid_{AY} \cdot Premium_{AY} \cdot ELR$$

R^{coll} – 0% credibility on losses-to-date

Credibility-Weighted Reserve Estimate

We can calculate a new, credibility-weighted estimate, based on R^{ind} and R^{coll}, that minimizes the mean squared error (MSE) and variance of the loss reserve estimate.

$$\boxed{R_i = Z_i \cdot R_i^{ind} + (1 - Z_i) \cdot R_i^{coll}}$$

Hürlimann uses three different credibility methods:

- Benktander (also in Mack (2000))
- Neuhaus
- Optimal credibility weighting (minimizes MSE)

Method	Z_i
Benktander(Z_i^{GB})	$\boxed{Z_i^{GB} = p_i}$
Neuhaus(Z_i^{WN})	$\boxed{Z_i^{WN} = p_i \cdot ELR}$
Optimal(Z_i^{opt})	$\boxed{Z_i^{opt} = \frac{p_i}{p_i + \sqrt{p_i}}}$

Advantages over the Mack (2000) approach

- Straightforward calculation of the optimal credibility weight
- Different actuaries get the same result using the collective loss ratio claims reserve with the same premiums (BF method requires an ELR assumption)

Advantage of the optimal credibility weight reserve (R^{opt})

- Minimizes MSE and variance of the loss reserve estimate
  - Note: the MSE from Benktander and Neuhaus are close to the optimal credibility MSE

Optimal Credibility Weights

Hürlimann derives the optimal credibility weights in sections 4-6. Many of the formulas are intermediary formulas in the derivation. For the exam, I would focus primarily on the final, simplified optimal credibility weight as well as the generalized optimal credibility formula (see the "Optimal Credibility Weights" recipe).

If we assume that the variance of the ultimate loss is the same as the variance of the burning cost ultimate loss estimate, $\text{Var}(U_i) = \text{Var}(U_i^{BC})$, we get the simplified optimal credibility weight formula. If we make a different assumption, then you need to use the generalized version of the formula.

You should definitely know the simplified optimal credibility weight formula. A potential twist to a question would be to use a different assumption, such as $\text{Var}(U_i) = 2 \times \text{Var}(U_i^{BC})$, and then use the generalized formula to calculate the optimal credibility weight.

Application to Standard Approaches

Hürlimann derived the optimal credibility weight formula for the loss ratio claims reserve approach. It can also be used with a more traditional approach, using LDFs to calculate the payout pattern (p_i^{CL}). With the LDF-based payout pattern, you can then calculate the reserve estimate as a credibility-weighting of the Chain Ladder and Cape Cod (or BF) reserve estimates using the Benktander, Neuhaus or optimal credibility weights.

Credibility-Weighted Cape Cod Approach

- Use LDFs to calculate the payout pattern (p_i^{CL})
- Calculate the ELR using the Cape Cod method

Credibility-Weighted Bornhuetter Ferguson Approach

- Use LDFs to calculate the payout pattern (p_i^{CL})
- The ELR is an assumption

Recipes for Calculation Problems

- Credible Loss Ratio Claims Reserve
- Optimal Credibility Weights

Brosius

Loss Development Using Credibility

Overview

Brosius introduces the Least Squares method for estimating loss reserves and compares this method to the traditional Chain Ladder and the Budgeted Loss (Expected Loss) methods. The key theme of this paper is that the Least Squares method is a credibility weighting of the Link Ratio (Chain Ladder) and Budgeted Loss methods.

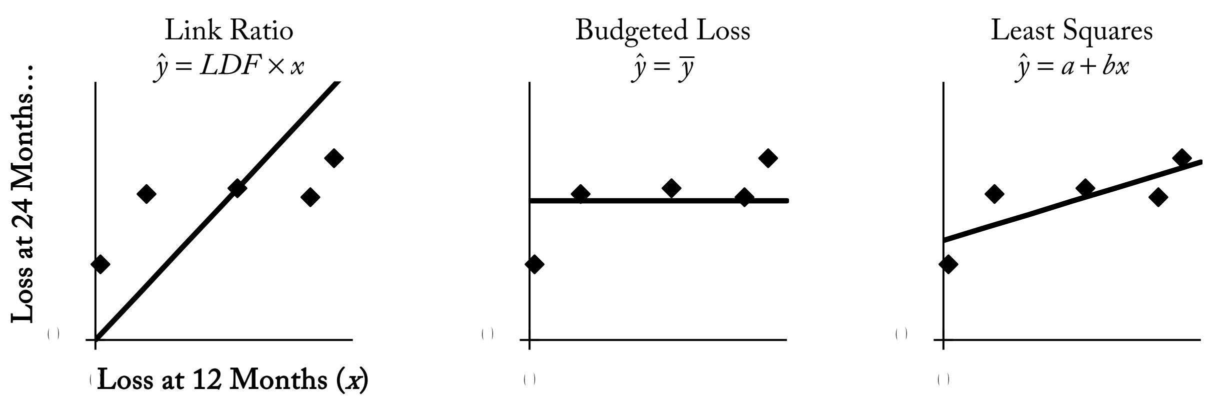
Least Squares Method

The Least Squares method fits a regression line through the data to estimate developed losses ($\hat{y}$).

$$b = \frac{\overline{xy} - \overline{x} \cdot \overline{y}}{\overline{x^2} - \overline{x}^2} \qquad a = \overline{y} - b \cdot \overline{x} \qquad \hat{y} = a + bx$$

See the "Brosius – Least Squares" recipe.

Comparison of Methods



Least Squares as Credibility Weighting

The Least Squares method is a credibility weighting of the Link Ratio and Budgeted Loss methods. The Link Ratio and Budgeted Loss methods represent the extremes:

- Link Ratio: Places 100% credibility on loss experience and 0% on expected losses
- Budgeted Loss: Places 0% credibility on loss experience and 100% on expected losses

<u>Least Squares Credibility Formula</u>

The Least Squares method is flexible and places more (or less) credibility on the loss experience as appropriate.

Below are the key formulas for calculating the credibility on the link ratio method. The factor *c* is just the LDF for the link ratio method. The credibility is the ratio of *b* to the LDF. The closer *b* is to the LDF, the higher the credibility weighting the least squares method places on the link ratio method.

$$c = LDF = \frac{\overline{y}}{\overline{x}}$$

$$Z = \frac{b}{c}$$

Credibility-weighted formula:

$$\hat{y} = Z \times \frac{x}{d} + (1-Z) \times \mathrm{E}\left[y\right]$$

$$\hat{y} = Z \times LDF \times x + (1-Z) \times \mathrm{E}\left[y\right]$$

Special Cases

- If x and y are completely uncorrelated, then b = 0, resulting in the Budgeted Loss method where $\hat{y} = a$.
- If the regression line fits through the origin, then a = 0, resulting in the Chain Ladder method where $\hat{y} = bx$.
- The Bornhuetter-Ferguson method is a special case of Least Squares where b = 1. The BF method can be problematic if negative loss development is expected. The Least Squares method would allow b to adapt to the observed data.

Potential Problems (and Fixes) with Least Squares

The intercept is negative (a < 0):

- This causes the estimate of developed losses ($\hat{y}$) to be negative for small values of *x.*
- Solution: Use the link ratio method instead.

The slope is negative (b < 0):

- This causes the estimate of *y* to decrease as *x* increases
- Solution: Use the budgeted loss method instead

Key Assumptions for Least Squares

Least Squares assumes a steady distribution of random variables X and Y

- Least Squares is inappropriate if there's a systematic shift in the book of business.

Advantages of Least Squares

- Least Squares is more flexible than the link ratio, budgeted loss, and BF methods.
- Least Squares is a credibility weighting of the link ratio and budgeted loss estimates. It gives more (or less) credibility to the loss experience (*x*) as appropriate.

- Least Squares produces more reasonable results when the data has severe random, year-to-year fluctuations (e.g. a small book of business or thin data).

<u>Adjustments to the data when using Least Squares</u>

- When using incurred loss data, the data should be adjusted for inflation so that all accident years are on a constant-dollar basis.
- If there is significant growth in the book of business, you should divide the data by an exposure basis.

Hugh White's Question

If reported losses(x) come in higher than expected, the different methods will estimate different changes to the outstanding loss reserve:

- **Budgeted Loss Method (fixed prior case)** – The ultimate loss estimate is fixed, so we <u>*decrease the loss reserve estimate*</u> by the same amount as the unexpected increase in reported losses. This method treats the increased loss as losses coming in faster than expected.

- **BF Method** – The ultimate loss estimate increases by the amount losses were greater than expected. The <u>*loss reserve is unchanged*</u>. The BF method treats the unexpected increased loss as a random fluctuation (e.g. a large loss).

- **Link Ratio Method (fixed reporting case)** – The ultimate loss estimate increases in proportion to the excess losses by applying the LDF, so we <u>*increase the loss reserve estimate*</u>. This method assumes that a fixed percentage of ultimate losses is reported, so if reported losses increases, the ultimate loss estimate will increase proportionally.

Theoretical Models – Testing Least Squares

The purpose of this section is to test the least squares model against a few different theoretical loss models. With a theoretical model, we can use Bayes' Theorem to calculate the "correct" loss model and then see whether the least squares, budgeted loss or link ratio models have the same form as the Bayesian approach.

Model	Form	Model Constraints
Least Squares	$\hat{y} = a + bx$	
Link Ratio	$\hat{y} = bx$	a = 0
Budgeted Loss	$\hat{y} = a$	b = 0
Bornhuetter-Ferguson	$\hat{y} = a + x$	b = 1

<u>Simple Model</u>

- The number of ultimate claims incurred (Y) is either 0 or 1 with equal probability
- If there is a claim (Y = 1), there is a 50% chance it's reported by year end (X)

Using Bayes' Theorem, the best estimate of ultimate claims given x is $\hat{y} = \frac{1}{3} + \frac{2}{3}x$. This is the form $\hat{y} = a + bx$, so only the Least Squares method is compatible.

Poisson - Binomial Model

- The number of ultimate claims incurred (Y) is Poisson with mean μ
- Any given claim has probability *d* of being reported by year end

Using Bayes' Theorem, the best estimate of ultimate claims is $\hat{y} = x + \mu(1-d)$. This is the same form as both the Least Squares method and BF method, since b = 1.

Negative Binomial – Binomial Model

- The number of ultimate claims incurred (Y) is Negative Binomial with parameters (*r*,*p*)
- Any given claim has probability *d* of being reported by year end

This model also has a Baysian estimate with the same form as the Least Squares method, but the other methods will be incorrect.

Linear Approximation (Bayesian Credibility Approach)

We can only calculate the true Bayesian estimate by assuming a distribution for Y and X|Y, but that's not practical. Instead, we're going to find the best linear approximation to the Bayesian estimate of ultimate losses with Bayesian credibility, L(x).

$$L(x) = \left(x - \mathrm{E}[X]\right)\frac{\mathrm{Cov}(X,Y)}{\mathrm{Var}(X)} + \mathrm{E}[Y]$$

Below is how a large reported loss (increasing *x*) can change the loss reserves, corresponding with the three different answers to Hugh White's question. For $x > \mathrm{E}[X]$:

- $\mathrm{Cov}(X,Y) < \mathrm{Var}(X)$: loss reserve ***decreases***
- $\mathrm{Cov}(X,Y) = \mathrm{Var}(X)$: loss reserve ***unaffected*** (ultimate loss increases by the increase to *x*)
- $\mathrm{Cov}(X,Y) > \mathrm{Var}(X)$: loss reserve ***increases***

Using loss data, we can estimate $\mathrm{Cov}(X,Y)$, $\mathrm{Var}(X)$, and $\mathrm{E}[Y]$, which gets us right back to the Least Squares method.

$$L(x) = \hat{y} = (x - \overline{x})\frac{\overline{xy} - \overline{x}\cdot\overline{y}}{\overline{x^2} - \overline{x}^2} + \overline{y}$$

The key point is that the ***least squares method is the best linear approximation to the Bayesian estimate***, although there will be sampling error in the parameter estimates of *a* and *b*.

Using simulated data from the Poisson-Binomial model, the Least Squares method fits the data better than the link ratio method and has a lower MSE.

Bayesian Credibility

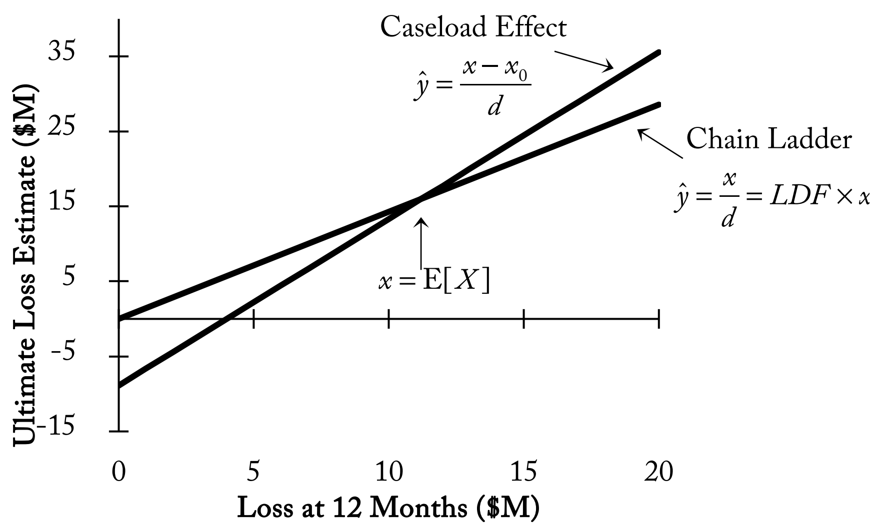
If the book of business changes significantly, we can't use the regular Least Squares method. But, if we make a few assumptions about the expected ultimate losses (Y) and the percent reported ($\frac{X}{Y}$), then we can calculate a Bayesian credibility estimate of ultimate losses (See the "Brosius – Bayesian Credibility" recipe).

Caseload Effect

The regular Bayesian credibility formula assumes that the expected percent of losses reported is the same no matter how large ultimate loss (Y) is. The caseload effect says that if ultimate loss is higher, then we would expect a lower percent of losses to be reported at time x (See the "Brosius – Caseload Effect" recipe).

Bayesian credibility still works, but the Bayesian credibility formula needs to be modified. Instead of using a fixed percent reported, the expected percent reported is lower if ultimate losses (Y) are higher. Below is a graphical view of the caseload effect and how the caseload effect estimate compares to the unmodified chain ladder estimate.

- If x > E[X], the caseload estimate will be higher than the unmodified chain ladder estimate.
- If x < E[X], the caseload estimate will be lower than the unmodified chain ladder estimate.



Recipes for Calculation Problems

- Least Squares Method
- Bayesian Credibility
- Caseload Effect

Friedland

Reserving for Reinsurance

Overview

Below are some of the key topics to understand from the Friedland paper:

- The types and functions of reinsurance
- Differences in data and reserving between reinsurers and primary insurers
- The comparison of the volatility in development factors and patterns between reinsurance, primary insurance, and more
- How different reinsurance contracts interact and how to calculate ceded loss reserves

Appropriate reserving for reinsurance is important for the following reinsurer stakeholders:

- **Internal Management** – Sound reserves affect all areas of reinsurer operations (pricing, underwriting, strategic planning, financial decision-making, …).
- **Investors** – Appropriately stated reserves are essential so that investors can properly evaluate the reinsurer's balance sheets and income statements for their decision-making.
- **Insurance Regulators** – Regulators rely on the financial statements of reinsurers to properly supervise the reinsurance market.
- **Rating Agencies** – If a reinsurer reports significant adverse reserve developments over time that reduce capital leaving the reinsurer in a weakened position, it could face a rating downgrade.

Functions of Reinsurance

- **Promote Stability** – Helps a ceding company stabilize loss experience over time and protect the ceding company from large unforeseeable losses. This can decrease the probability of ruin.
- **Increase Capacity** – By ceding a portion of all policies or its larger policies, a ceding company can increase its capacity to write more business, particularly at higher policy limits.
- **Protect against Catastrophes** – Reinsurance can protect ceding companies from catastrophic loss events as well as protect against casualty loss occurrences with multiple insureds (like terrorism).
- **Manage Capital and Solvency Margin** –
    - Reinsurance can help a ceding company pass the risk of large losses to the reinsurer which frees up capital since less capital will be required to support the policies written.
    - The ceded commission acts as a transfer of statutory surplus from the reinsurer to the cedent, which can manage financial results.
    - Premium ceded also reduces the cedent's net premium-to-surplus ratio (solvency margin), which allows the cedent to write more business.

- **Access Technical Expertise** – Reinsurers have technical expertise in underwriting, marketing, claims, loss prevention, pricing, and entering new lines/regions that can help small insurers.
- **Other Functions** – Reinsurance can help a ceding company withdraw from a line of business, geographic area, or production source.

Types of Reinsurance

Reinsurance is categorized as **Treaty** or **Facultative** and **Proportional** or **Non-Proportional**.

Treaty Reinsurance

- The ceding company cedes all business arising from the lines of business that fall within the terms of the treaty subject to treaty limits.
- There is no underwriting by the reinsurer of individual risks within the treaty terms.
- The cedent has an obligation to cede a risk under the treaty terms and the reinsurer has an obligation to automatically accept it.

Facultative Reinsurance

- Both the ceding company and reinsurer have the option (faculty) to accept or reject individual submissions and an individual reinsurance agreement is negotiated for each policy ceded.
- Primarily used to increase capacity, typically for high-value and hazardous commercial risks.

Proportional Reinsurance

- Increases capacity and manages capital and solvency margins to provide surplus relief
- Both premiums and losses are shared between the cedent and reinsurer based on the cession percentage. The reinsurer pays a **ceding commission** to reimburse the cedent for expenses underlying the policy.

Types of Proportional Reinsurance:

- **Quota Share** – The ceding company cedes an agreed percentage of each risk (premiums and losses) to the reinsurer for the lines of business in the contract, typically a treaty.
- **Surplus Share** – The cedent cedes the surplus amount of a risk above the retained line subject to a maximum ceded percentage and limit. The proportion ceded is different for different insured policies according to the underlying policy limits and acts like a variable quota share.

$$Proportion\ Ceded = \frac{Policy\ Limit - Retained\ Line}{Policy\ Limit}$$

Non-Proportional Reinsurance (Excess of Loss)

- Provides stability by protecting losses above a limit for risks ceded
- Loss ceded is based on the size of loss and the premium is not proportional to the coverage limits

Types of Non-Proportional Reinsurance:

- **Excess per Risk** – Excess-of-loss reinsurance above a retention for *each risk*
  - Primarily to protect property exposures (e.g. 7M excess 3M on property policies with 10M policy limits)
  - Allows ceding companies to write larger risks (increase capacity)
- **Excess per Occurrence and Catastrophe** – For a loss occurrence, the ceding company retains the retention and cedes the loss excess the retention to the reinsurer up to the reinsurance limit.
  - **Excess per Occurrence** – Protects a cedent from the accumulation of losses in a single loss occurrence.
  - **Catastrophe Reinsurance** – Form of Excess per Occurrence for a single catastrophic event or series of events. Most allow for reinstatement after a full limit loss.
- **Annual Aggregate Excess of Loss (stop-loss)** – Guarantees a ceding company's losses won't exceed a predetermined threshold (percent of premium or fixed dollar amount)
  - The reinsurer indemnifies for losses above the aggregate value
  - Protects net results (other reinsurance inures to the benefit of the Agg. Excess of Loss)
  - The best option to protect capital but can be very expensive or unavailable
- **Clash** – Casualty reinsurance contract that attaches above all other policy limits. It protects a ceding company when there are multiple claims from multiple insureds for the same catastrophe and its reinsurance policy doesn't fully reimburse the insurer.
  - Components of a clash event:
    - Loss must have multiple policies by one insured or similar policies held by multiple insureds
    - The losses are traceable to and the direct consequence of a specific event
    - The event must take place within a specific timeframe

Finite Risk Reinsurance

This type of reinsurance takes the time value of money into account. Features include:

- Risk transfer and risk financing in a multi-year contract
- Incorporates the time value of money and investment income
- Limited assumption of risk by the reinsurer
- Reinsurer and ceding company share results

Includes run-off solutions, which transfer reserve development risk to the reinsurer. Reasons for run-off include corporate restructuring, mergers & acquisitions, discontinuation of lines of business, erratic changes in the valuation/cost of a liability, …

Loss Portfolio Transfers

- Transfers all (or a portion) of liability for future loss payments on losses already incurred

- Relieves cedent of uncertainty in loss reserves and relieves capital

Adverse Development Cover

- Ceding company is reimbursed for losses excess a retention, but there's no transfer of the loss reserves to the reinsurer
- Often used for Mergers & Acquisitions to transfer the risks of timing and adverse reserve development

Reinsurance Concepts and Contract Provisions

Inure to the Benefit of

The concept of "inuring to the benefit of" specifies whether a treaty takes effect to the benefit of the reinsurer or the reinsured.

For a reinsurance Treaty A:

- If other reinsurances apply first to reduce the loss subject to Treaty A, then the other reinsurance contracts *inure to the benefit of the reinsurer* of Treaty A.
- If other reinsurances are ignored with respect to Treaty A (they don't lower the loss subject to Treaty A), then the other reinsurance contracts *inure to the benefit of the ceding company*.

Losses-Occurring During vs Risks-Attaching

- **Losses-Occurring During** – Reinsurance coverage for all losses that occur between the inception and expiration of the reinsurance contract, regardless of when the underlying policy was issued.
- **Risks-Attaching** – Reinsurance coverage for losses on underlying policies with inception dates during the reinsurance contract's effective period. The underlying policies "attach" to the contract.

Subscription Percentage

A subscription policy is a reinsurance policy where risk is shared by multiple reinsurers. Each reinsurer has a subscription percentage to the contract.

Reasons for this approach include:

- When coverage is more than one reinsurer is willing to assume
- Allows the cedent to diversify credit risk (the risk that a reinsurer can't pay reinsurance recoveries)

Commutation Clause

A commutation is the cancellation of a reinsurance contract. The reinsurer pays the present value of reinsurance recoveries not yet due for the termination of the contract and all future obligations.

Both reinsurers and ceding companies have reasons for commutations:

For a Ceding Company	For a Reinsurer
• To exit a line of business or region • To manage reserves for transfer or sale • To avoid credit risk of a reinsurer • To better manage claims and claims-related expenses	• To terminate a relationship with a ceding company • To protect itself from the insolvency of a ceding company • To avoid disputes with the cedent about future loss development

Sufficient and Reliable Data

Sufficiency

Data are sufficient if they included all information needed for the actuarial work.

For the development method:

- Reinsurance data may not be appropriate for the underlying development method assumptions because of its manuscript nature (custom-written) and due to operational changes at ceding companies, the reinsurer or both
- Changes at the ceding company level can violate the assumption of consistency in mix of business, attachment points, limits, claims processing, etc.

Reliability

Data are reliable if they are sufficiently complete, consistent, and accurate for the purposes of the work.

- Data should be validated: Reviewed for consistency, completeness, and accuracy.

Reliability challenges for reinsurers vs. primary insurers:

- Each ceding company/broker has different IT systems, terminology, etc.
- Bordereau reporting can differ (types of data, labeling, frequency)
- Reporting lags
  - Claims are reported first to ceding company before being reported to the reinsurer
  - Long-tailed nature of certain reinsurance like excess per risk and catastrophe reinsurance
  - Bordereau reporting: losses are only reported quarterly or more infrequent schedule
- Gaps in reporting of critical claims and claims expense information by the ceding company
- Manuscript nature of reinsurance policies

Homogeneity and Credibility of Data

Homogeneity

Homogeneous Risk Group (HRG) – Set of (re)insurance obligations with similar risk characteristics to allow for reliable valuation of unpaid losses or technical provisions.

Data should be segmented into groups with similar characteristics of loss experience such as consistency of coverage, similar reporting/payment patterns, ability to develop appropriate case outstanding for claims, severity, and volume of losses in the group.

Credibility

Credibility – A measure of the predictive value for a set of data.

Credibility for a homogeneous risk group **increases** with:

- **Increasing** homogeneity of the data within a group
- **Increasing** the volume of data in a group

If groups are too granularly defined, the volume of data in each group may be too low for a reliable analysis.

Important Variables for Partitioning the Reinsurance Portfolio

- **Line of business** (property, casualty, …)
- **Type of contract** (facultative, treaty, …)
- **Type of reinsurance cover** (quota share, excess per-occurrence, CAT, …)
- **Primary line of business** – for casualty
- **Attachment point** – for casualty
- **Contract terms** (flat-rated, retro-rated, claims-made, …)
- **Type of cedent** (small, large, …)
- **Intermediary**

Organization of Data by Experience Period

Accident Year Aggregation

Losses are grouped by date of occurrence and calendar year earned premium is used to approximately match accident year losses.

Advantages	Disadvantages
• Easy to achieve and understand • Losses over shorter time frame than underwriting year so losses can be reliably estimated sooner • Industry benchmarks are based on AY • Valuable when there are economic/regulatory changes or major loss events	• Potential mismatch of losses and premiums

Underwriting Year Aggregation

Losses are grouped by the year in which the reinsurance policy became effective (inception date).

Advantages	Disadvantages
• True match of losses and premiums • Valuable when underwriting or pricing changes occur	• Extended timeframe for losses tied to UW year • Difficult to isolate the effect of a single large loss event

Types of Data

ULAE – Usually excluded from reinsurance coverage.

ALAE – Generally three possible reinsurance treatments:

- Included with claim amount to determine excess of loss coverage
- Included on a pro-rata basis (% of reinsured loss / total loss)
- Not included in coverage

Multiple currencies – Loss data may be in different currencies. There are two approaches:

- Separate data by currency, then combine the data after translating to a common currency using the exchange rate at a single point in time
- Aggregate losses are based on the ceding company's currency of origin

Large losses – Exclude large losses from initial projections and then add in case-specific projections of the reported portion for large losses and a smoothed provision for the IBNR portion of the large losses.

Recoveries (deductibles, salvage & subrogation) – Generally recoveries are applied before reinsurance.

Data Challenges for Reinsurers

- **Influence of Change in Operations and Environment**
  - Operational changes for ceding insurers and reinsurers
  - Changes in the legal/economic environment of ceding companies that impact losses
- **Other Experience Typically Excluded**
  - Actuary may exclude discontinued business (run-off) from the data analysis
- **Reporting Lags**
  - Losses first reported to ceding company before they're reported to the reinsurer
  - Losses may not be reported to the reinsurer until a claim hits a certain threshold
- **Heterogeneity of Contract Wording**
  - The "manuscript nature" of reinsurance contracts means contract wording can be different by contract making it more difficult to aggregate similar data

External Sources of Data

Actuaries at smaller reinsurers often use external data sources to help analyze development or tail factors, trend rates, expected loss ratios, etc. Below are some external sources of data:

- Reinsurance Association of America (RAA)
- Best's Aggregates & Averages
- Reports from global brokers or reinsurers
- Other internet searches

External data may be misleading or irrelevant due to differences in:

- Manuscript wording/term of reinsurance contracts
- Mix of assumed business (differences in industry, region, attachment points, policy limits)
- Types of reinsurance (treaty vs. facultative, proportional vs. non-proportional)
- Underwriting processes
- Claims management differences
- Coding and IT system differences

Methods Used

Development Method

- Assumes future development is like prior years' development and losses to date are predictive of losses yet to be observed
- Assumes consistency across experience period of claims processing, mix of business, policy limits, reinsurance coverage, etc.

Expected Method

Applies an expected loss ratio to earned premium to estimate expected losses.

Often used when:

- Entering a new line of business or region
- When historical losses are irrelevant to project future losses due to changes in strategy, operations, or environment
- When the development method isn't appropriate for immature periods because development factors are too highly leveraged
- When data are unavailable for other methods

Bornhuetter-Ferguson Method

- Assumes unreported (or unpaid) loss will develop based on expected loss.

- Relies on both a selected loss development pattern and expected loss estimate

Differences in Method Assumptions for Reinsurance vs Primary Insurance

- For a similar line: **LDFs at immature ages are often higher** (more leveraged) for reinsurance due to reporting lags
- Loss trend factors are often **higher for excess of loss reinsurance** than primary insurance
- Less precision in premium on-level factors for rate changes for reinsurance vs. primary insurance
- Limited use of adjustment factors for tort/product reform for reinsurance vs primary insurance

Effect of Changes in Currency Exchange Rates

Many global reinsurers review triangles **at the prevailing** exchange rates.

- This prevents distortions in age-to-age factors due to fluctuating exchange rates year-to-year.

Comparisons of Development Factors and Patterns

Reinsurance vs. Primary Insurance (Similar Type of Business)

More volatility in age-to-age factors at earlier maturities for:

- Reinsurance compared to primary insurance
- Paid losses compared to reported losses

Greater volatility means more uncertainty in age-to-age factor selection and projected ultimate losses.

Longer reporting/payment patterns for reinsurance due to lags in reporting to the reinsurer.

Proportional vs. Non-Proportional Reinsurance (Same Line of Business)

For the same line of business:

- Significantly more volatility in age-to-age factors for non-proportional treaty and facultative reinsurance than for proportional treaty reinsurance
- CDFs are greater for non-proportional treaty and facultative reinsurance (longer dev. patterns)
- Also - More volatility in ratios of paid-to-reported losses for non-proportional and facultative

A key difference is that proportional reinsurance is ground-up and non-proportional is excess of loss.

Takeaway: The greater volatility in age-to-age factors and diagnostics results in greater uncertainty in projected ultimate loss from the development method.

Property Reinsurance excl. Catastrophe vs. Property Reinsurance Catastrophe

- Reinsurer carried reserves for catastrophe losses are usually based on ground-up exposure-based assessments using info from ceding companies by contract (NOT the development method)

- The impact of catastrophe events at different times of the year impacts development and age-to-age factors for different years
  - Development method assumptions may not be appropriate
- Volatility is much higher for catastrophe vs. ex-catastrophe property reinsurance.

Takeaway: Methods using age-to-age factors are often not appropriate for property catastrophe.

Implications of Volatility in Loss Development

- Greater volatility in age-to-age factors can lead to greater uncertainty in projections of ultimate loss (and therefore unpaid loss) because:
  - Development methods and other methods rely on the age-to-age factors that have greater volatility (B-F method does and the expected method often does to set ELRs)
  - Greater volatility in indicated ultimate loss ratios is often used to select ELRs for the expected and B-F methods

Takeaway: Greater volatility in projected ultimate loss results in a greater range in indicated IBNR and Total Unpaid for:

- Reinsurance compared to primary insurance
- Non-proportional treaty and facultative compared to proportional treaty reinsurance
- Catastrophe reinsurance compared to excluding catastrophe reinsurance for property

Quota Share and Stop Loss Reinsurance Examples

Quota Share Reinsurance

- Apply the %ceded (or 1 - %retained) to gross ultimate loss, case reserves, paid loss, and IBNR to get the ceded values.
- The %ceded may change over time, so calculations are applied by year

Stop-Loss Reinsurance

- Stop-Loss reinsurance applies after all other reinsurance and protects the net result of a ceding company
- Once a ceding company breaches stop-loss coverage, the reinsurer will often increase the price or the attachment point (or both)