CAS Study Note – Exam 7 Reserving for Reinsurance

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Exhibits available online.

Preface

As the author of the Casualty Actuarial Society's (CAS's) text on reserving, I am honored to prepare this new text on reserving for reinsurance. In many ways, I view this text as a supplement to my earlier work, *Estimating Unpaid Claims Using Basic Techniques*, and I strongly encourage readers to be familiar with that text prior to this one.

With the goal of having this text used by actuaries and actuarial candidates around the world, I strive to present concepts in a simple and straightforward manner, particularly for those for whom English may not be their first spoken language. With this global mindset, I also chose not to use any currency in the examples.

I wish to express sincere thanks to all the members of the CAS educational committee who helped guide this text in its initial development and through countless reviews: Arthur Zaremba, Eric Blancke, Jill Labbadia, Jonathan Schreck, and Fran Sarrel. Additional thanks to these CAS members for reviewing this document: Jackie Ruan, Zora Law, Eric Lam, Meg Glenn, Kenneth Hsu and Joseph Lindner.

I also express sincere thanks to Wesley Griffiths, who worked with me as a Staff Actuary at the CAS.

Readers should be aware that figures in the supporting tables and exhibits are often carried to a greater number of decimals than shown. Thus, totals and calculations may not agree exactly due to rounding differences.

Please notify the CAS of any errors so that this text can be corrected in subsequent editions.

—Jacqueline Frank Friedland, FCAS, FCIA, FSA

Chapter 1 – Introduction

The objective of this text is to address the estimation of unpaid losses[1] from the perspective of reinsurance. Reinsurance, which is insurance for insurers, is critical for the operation of the insurance industry as a whole. Through reinsurance, the cost of risk is spread across the marketplace, often globally, and the financial effect of an insured event is lessened for a single insurer[2] or economy. This text is intended for actuaries working with reinsurers as well as for actuaries working with primary insurers who estimate losses that are ceded to reinsurers. The text is also intended for actuaries working with self-insurers and captive insurers[3] who utilize reinsurance.

It is assumed that the reader of this text is knowledgeable about basic reserving, including typical data requirements, key assumptions, and traditional methodologies (such as the chain ladder, expected loss, and Bornhuetter-Ferguson techniques). Thus, this text focuses on the differences in reserving for reinsurance versus primary insurance and not on the detailed mechanics of the traditional unpaid losses projection techniques.[4]

Like insurers, reinsurers do not know the true cost of goods sold during a financial reporting period until years, possibly decades, later – after all claims are settled. Thus, it is critical that insurers and reinsurers maintain robust processes for the estimation of unpaid losses. Most frequently, the actuary estimates unpaid losses by subtracting paid losses from projections of ultimate losses. This text explores numerous considerations for such projections and issues related to data, understanding the environment (internal and external to the reinsurer), and the selection of methodology and assumptions. In this text, the term **reserves** refers to an amount booked in a financial statement, which may differ from the actuary's estimate of unpaid losses.[5]

Appropriate estimates of unpaid losses and reserves are essential for the internal management of a reinsurer as well as for its key stakeholders.

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[1] The estimation of unpaid losses is also referred to as reserving.

[2] In actuarial and accounting literature and standards, the term insurer is often used to refer to primary insurers, reinsurers, captive insurers, and self-insurers. Given that this text focuses specifically on reinsurance, the term reinsurer is generally used to differentiate reinsurers from other insurers.

[3] The International Risk Management Institute (IRMI) Glossary defines a captive insurer as "an insurance company that has as its primary purpose the financing of the risks of its owners or participants. Typically licensed under special purpose insurer laws and operated under a different regulatory system than commercial insurers. The intention of such special purpose licensing laws and regulations is that the captive provides insurance to sophisticated insureds that require less policyholder protection than the general public" (See https://www.irmi.com/term/insurance-definitions/captive.)

[4] For further information, see Jacqueline Friedland, *Estimating Unpaid Claims Using Basic Techniques* (Arlington, VA: Casualty Actuarial Society, 2010).

[5] This use of the term reserves is consistent with the U.S. Actuarial Standards Board's *Actuarial Standard of Practice (ASOP) 43– Property/Casualty Unpaid Claim Estimates.*

- Internal management requires sound reserves because they affect virtually every area of a reinsurer's operations, including but not limited to pricing, underwriting, strategic planning, and financial decision making.
- Investors require appropriate reserves because they are essential to the evaluation of a company's financial health. Reserves that are either inadequate or excessive can lead to misstated balance sheets and income statements for the reinsurer, and key financial metrics used by investors could be misleading. A reinsurer with insufficient reserves could present itself in a stronger position than it truly is. Conversely, a reinsurer with excessive reserves may appear to be in a weaker position than its true state. Both situations could affect investors' decisions related to the reinsurer.
- Insurance regulators rely on the financial statements of reinsurers to carry out their supervisory role. Inappropriate reserves could result in a misstatement of the true financial position of a reinsurer. If a financially struggling reinsurer is masking its true state with inadequate reserves, a regulator may not become involved until it is too late to help the reinsurer regain its strength and protect the public's interests.
- Rating agencies evaluate movement over time in reinsurers' reserves. A reinsurer who reports significant adverse reserve development that results in reduced capital and a weakened financial position could face a downgrade from rating agencies. A rating downgrade, or even the threat of a downgrade, threatens a reinsurer's ability to attract and retain business because primary insurers typically have requirements for minimum ratings of their reinsurers.

Further requirements for appropriate reserves emanate from jurisdictional law (i.e., state, provincial, or national), the National Association of Insurance Commissioners for U.S. reinsurers, accounting standards such as the U.S. Generally Accepted Accounting Principles (GAAP) and International Financial Reporting Standards (IFRS), and actuarial standards of practice.

This chapter is organized in the following sections:

- Basic reinsurance terminology
- Functions of reinsurance
- Major types of reinsurance
- Reinsurance concepts and contract provisions influencing the estimation of unpaid losses

Basic Reinsurance Terminology

Reinsurance has its own vocabulary, so it is important to start with basic reinsurance terms before a discussion of the functions and types of reinsurance. New terms are shown in bold when defined, which may not be at the term's first use.

Reinsurance is a form of insurance in which the reinsurer, in consideration of a premium, agrees to indemnify the reinsured for part or all of the loss that the reinsured may sustain under the policy or policies that it has issued. The **reinsured**, which is the insurer that cedes its business (i.e., reinsures its

liability) with another, is also referred to as the **ceding company**, or the **cedent**. Reinsurance is used by primary insurers, captive insurers, self-insurers, and even by reinsurers. Given the range of organizations that purchase reinsurance, the term ceding company is typically used in this text to refer to those who purchase reinsurance. The **reinsurer** is the insurer that accepts all or part of the insurance liabilities of the ceding company for a stated premium.

In the context of reinsurance, insurers and reinsurers refer to business that is ceded and assumed. For business **ceded**, the risk is transferred from the ceding company to the reinsurer. Ceded insurance policies are referred to as the **subject policies** or the **underlying policies**. In the context of IFRS 17–Insurance Contracts, ceded reinsurance contracts are referred to as **reinsurance contracts held**. A reinsurer **assumes** the business transferred through reinsurance from the insurer.

A reinsurer can transfer risks it has reinsured to another reinsurer through a **retrocession**, which is the reinsuring of reinsurance. In a retrocession, the ceding reinsurer is known as the **retrocedent,** and a **retrocessionaire** is the assuming reinsurer.

When working with data and reporting on financial results, the terms **gross**, **net**, and **ceded** (losses and premiums) have slightly different meanings when used with primary insurers and reinsurers. When used for a primary insurer,

- Gross experience refers to the sum of direct and assumed business,
- Ceded experience refers to business transferred through reinsurance, and
- Net experience is equal to gross less ceded experience.

In a reinsurance context,

- Gross experience refers to assumed business,
- Ceded experience refers to business transferred through retrocessions, and
- Net experience is equal to gross less ceded experience.

In a reinsurance context, the **retention** is the amount of insurance liability or loss that the ceding company retains for its own account after consideration for reinsurance. Depending on the type of reinsurance, the retention can be expressed as a percentage or a dollar amount. The ceding company's retention may also be referred to as the **attachment point**, which is the point at which reinsurance begins to apply.

The **working layer** is a dollar range in which the insurer (or reinsurer) expects relatively predictable loss experience with a fairly high level of loss frequency. The determination of the boundary of a working

layer is subjective and depends on an organization's unique risk appetite.[6] A layer that the ceding company determines to be a working layer would typically be different from a layer that a reinsurer determines to be a working layer. Frequently, a ceding company retains losses within its working layer and cedes losses (or a portion of losses) in excess of such a working layer.

Reinsurers often receive data by **bordereau** (plural **bordereaux**) from ceding companies or the brokers of their ceding companies. Bordereau is defined by the International Risk Management Institute (IRMI) as follows:

> Furnished periodically by the reinsured, a detailed report of insurance premiums or losses affected by reinsurance. A premium bordereau contains a detailed list of policies (or bonds) reinsured under a reinsurance treaty during the reporting period, reflecting such information as the name and address of the primary insured, the amount and location of the risk, the effective and termination dates of the primary insurance, the amount reinsured and the reinsurance premium applicable thereto. A loss bordereau contains a detailed list of claims and claims expenses outstanding and paid by the reinsured during the reporting period, reflecting the amount of reinsurance indemnity applicable thereto. Bordereau reporting is primarily applicable to pro rata reinsurance arrangements and to a large extent has been supplanted by summary reporting.[7]

Chapter 2 expands on issues related to reinsurance bordereaux.

The final term to be defined in this section is counterparty default risk, or simply default risk. In a reinsurance context, **counterparty default risk** is the risk that the reinsurer is unable to meet its contractual obligations. In all situations, to the extent that a reinsurer is unable to meet its obligations, the assumed liability falls back to the ceding company who has the contractual relationships with the underlying insured or policyholder.

Functions of Reinsurance

Reinsurance is used to spread risk by transferring some of the risk from the ceding company to the reinsurer or reinsurers. In *Foundations of Casualty Actuarial Science,* Gary Patrik states:

> The nature and purpose of reinsurance is to reduce the financial cost to insurance companies arising from the potential occurrence of specified insurance claims, thus further enhancing innovation, competition, and efficiency in the marketplace. The cession of shares of liability

[6] The IRMI Glossary defines risk appetite as "the degree to which an organization's management is willing to accept the uncertainty of loss for a given risk when it has the option to pay a fixed sum to transfer that risk to an insurer" (see https://www.irmi.com/term/insurance-definitions/risk-appetite.)

[7] Robert Strain, "Reinsurance Terminology Explained: Bordereau and Other Terms of Art," IRMI Expert Commentary, https://www.irmi.com/articles/expert-commentary/reinsurance-terminology-explained-bordereau.

> spreads risk further throughout the insurance system. Just as an individual or company purchases an insurance policy from an insurer, an insurance company may purchase fairly comprehensive reinsurance from one or more reinsurers.[8]

Ceding companies purchase reinsurance for five primary reasons:

- Promote stability.
- Increase capacity.
- Protect against catastrophe.
- Manage capital and solvency margin.
- Access technical expertise.

Promote Stability

Reinsurance is used to help ceding companies stabilize their loss experience within a year and from year to year. Ceding companies typically retain smaller, more predictable claims and cede those claims that are more unusual and infrequent. In this manner, reinsurance can protect the ceding company from shocks associated with large unforeseeable losses. Some ceding companies use reinsurance with relatively low attachment points to provide stability even for losses that are not considered large or unforeseeable. With reinsurance, results can be stabilized by limiting a ceding company's losses following a single event or the accumulation of losses arising from multiple events. By promoting stability, reinsurance can decrease the probability of ruin for a ceding company.

Increase Capacity

Reinsurance expands a ceding company's ability to assume risk by ceding a portion of all its policies or simply its larger policies. Ceding companies often purchase reinsurance to increase their capacity for accepting more business, particularly higher limit policies. For example, assume a large primary insurer was approached to write commercial property insurance for a sports stadium with policy limits of 500 million. Further assume that the primary insurer's risk appetite framework established a net retention of 5 million. Thus, to be able to offer an insurance solution for the stadium, the primary insurer could seek reinsurance from one or more reinsurers to provide the additional 495 million limits of coverage.

The ability for a cedent to offer more capacity on an individual account can be very important, especially for quality accounts that the ceding company might otherwise not be able to write. Furthermore, by providing capacity, reinsurers help facilitate the competition of small insurers with large insurers who, by their nature, can and do generally accept more risk.

[8] Patrik, "Reinsurance," in *Foundations of Casualty Actuarial Science*, 4th ed. (Arlington, VA: CAS, 2001), 344.

Protect Against Catastrophes

Protection from catastrophes, both natural and man-made, is a major purpose of reinsurance. Reinsurance is used to protect ceding companies from a single catastrophic loss event (such as a hurricane or typhoon, earthquake, or wildfire) as well as multiple large loss events (such as multiple hurricanes or typhoons within a single year or a season of multiple wildfires in a single state, province, or country). Reinsurance is also used to protect against casualty losses in which multiple insureds are involved in one occurrence (such as terrorism attacks or vehicle accidents in which many people are injured).

Manage Capital and Solvency Margin

A ceding company can avoid large losses by passing risk to a reinsurer and thus freeing up additional capital. Insurers (including reinsurers) are required by law and regulation to have sufficient capital for potential future claims on all policies written. According to the Insurance Information Institute, "If the insurer can reduce its responsibility, or liability, for these claims by transferring a part of the liability to another insurer, it can lower the amount of capital it must maintain to satisfy regulators that it is in good financial health and will be able to pay the claims of its policyholders."[9]

Through the purchase of some types of reinsurance, a ceding company can accept new risks and avoid the need to raise additional capital. Patrik describes the reinsurance function of managing financial results as follows:

> Reinsurance can alter the timing of income, enhance statutory and/or GAAP surplus, and improve various financial ratios by which insurers are judged. An insurance company with a growing book of business whose growth is stressing their surplus can cede part of their liability to a reinsurer to make use of the reinsurer's surplus. This is essentially a loan of surplus from the reinsurer to the cedant until the cedant's surplus is large enough to support the new business.[10]

Financial results of the ceding company are managed because the ceded commission on the unearned premium reserve transfers statutory surplus from the reinsurer to the cedent. The premium ceded also reduces the ceding company's net premium-to-surplus ratio, referred to as the solvency margin. With a lower premium-to-surplus ratio, the ceding company can write more business.

Access Technical Expertise

An important function of reinsurance is access to the technical expertise of reinsurers, particularly in areas of underwriting, marketing, claims, loss prevention, and pricing. In an IRMI Expert Commentary article on reinsurance, Larry Schiffer states, "Quality reinsurers provide special expertise to their direct

[9] Quoted in Bethan Moorcraft, "Facultative and Treaty Reinsurance: The Differences Explained," *Insurance Business Canada*, June 3, 2019, https://www.insurancebusinessmag.com/ca/guides/facultative-and-treaty-reinsurance-the-differences-explained-168931.aspx.

[10] Patrik, "Reinsurance," 345–46.

insurer clients and assist the direct insurer in providing the best possible protection and risk management for the direct insurer's own clients."[11]

This can be particularly important for small insurers, for whom reinsurers often provide engineering, actuarial, and claims expertise and training. Insurers seeking to enter new lines of business or regions where they do not have experience often turn to reinsurers with market leadership for insight and knowledge. The expertise of reinsurers can be used to help ceding companies explore their underwriting opportunities and ultimately their book of business.

Other Functions of Reinsurance

Reinsurance can be used to facilitate a ceding company's withdrawal from a line of business, geographic area, or a production source. Finally, there are certain market conditions where reinsurance is used for arbitrage when a ceding company believes that additional profits can be garnered by purchasing reinsurance for a value less than the premium the cedent collects from its policyholders.

Different types of reinsurance serve these varied purposes to different degrees.

[11] Schiffer, "Reinsurance Matters," IRMI Expert Commentary, March 2000, https://www.irmi.com/articles/expert-commentary/reinsurance-matters.

Types of Reinsurance

Insurers frequently purchase a variety of reinsurance contracts to serve the functions of stability, capacity, catastrophe protection, financing, and expertise. It is critical for the actuary to understand details of the types of reinsurance used to cede and assume business as there are likely implications on actuarial work, particularly on the data required, the selection of methodology, and the development of assumptions.

An important characteristic of reinsurance contracts is their manuscript nature, whereby reinsurance contracts are developed to meet the specific needs of the ceding company and the reinsurer(s). This is quite different from many primary insurance contracts, particularly personal auto[12] and personal property[13] policies, where the contract is the same for all insureds, with the exception minors such as deductible and policy limits and the use of standard endorsements. Given the tailored nature of reinsurance contracts, it can be challenging to generalize about the types of reinsurance. Thus, it should be understood that exceptions to the material presented in this section are common.

Reinsurance is typically categorized as treaty or facultative and as proportional or non-proportional.

Treaty and Facultative Reinsurance

Treaty Reinsurance

Treaty reinsurance is a type of reinsurance in which the ceding company enters into a contractual agreement with one or more reinsurers to cede all business arising from certain lines of business as specified in the contract. The treaty may span one year or multiple years. In treaty reinsurance, the ceding company agrees to cede and the reinsurers agree to assume all the business written by the ceding company that falls within the terms of the treaty, subject to the limits specified in the treaty. With treaty reinsurance, the reinsurer agrees to accept policies that the ceding company has not yet written to the extent that the risks fall within the treaty's terms.

The most important characteristic of treaty reinsurance is the absence of individual underwriting by the reinsurer. In essence, treaty reinsurance transfers underwriting risk from the ceding company to the reinsurer, leaving the reinsurer exposed to the possibility that the initial underwriting process did not adequately evaluate the risks insured.

Facultative Reinsurance

Facultative reinsurance differs from treaty reinsurance in that a facultative cession is not automatic. The word facultative connotes that both the ceding company and the reinsurer usually have the faculty (i.e., option) of accepting or rejecting the individual submission. Facultative reinsurance is distinguished from

[12] Auto insurance is also referred to as motor and car insurance.

[13] Personal property insurance is also referred to as homeowners, home, and household insurance.

treaty reinsurance where there is an obligation for the cedant to cede a risk or for the reinsurer to accept the ceding risk. In facultative reinsurance, a submission, acceptance, and resulting agreement are required for each individual risk or a defined group of risks that the ceding company wants to reinsure, and the ceding company negotiates an individual reinsurance agreement for each policy it reinsures.

For facultative coverage, a certificate of reinsurance is frequently used. The **certificate** is a record of reinsurance coverage pending replacement by a formal reinsurance contract. With facultative reinsurance, the ceding company can acknowledge acceptance of terms, with the reinsurer's obligation contingent on validity of key information that is stated in the certificate.[14]

The primary purpose of facultative reinsurance is capacity. Facultative contracts can be tailored to the specific circumstances, and thus are typically used for high-value and hazardous commercial risks. Facultative reinsurance has the potential for adverse selection. However, unlike treaty reinsurance, a reinsurer may conduct its own underwriting with facultative reinsurance and thus mitigate the risk of adverse selection.

Examples of Treaty and Facultative Reinsurance

Generalizing about reinsurance is challenging given the tailored nature of most reinsurance contracts. Nevertheless, the following examples help demonstrate common uses of facultative and treaty reinsurance:

- A ceding company maintains property treaty reinsurance for all policyholders with total insured values (TIV) less than 25 million. Reinsurance coverage for all policyholders with TIV of 25 million or more is placed through the facultative market.
- A ceding company maintains casualty treaty reinsurance for automobile risks and uses facultative reinsurance for environmental liability risks.
- A ceding company maintains workers' compensation treaty reinsurance for employers with less than 1,000 employees. Workers' compensation policies for employers with more than 1,000 employees are protected with facultative reinsurance.

For the treaty reinsurance mentioned above, all ceded risks would be subject to the terms and limits of each treaty (i.e., property, casualty, and workers' compensation). For the facultative reinsurance, terms and conditions would be tailored to meet the unique situations of the ceded risks.

Hybrid of Treaty and Facultative Reinsurance

Hybrid contracts, which blend characteristics of treaty and facultative reinsurance, can be used to provide capacity and some degree of stabilization as they can cover many underlying policies. Patrik

[14] "Certificate of Reinsurance," IRMI Glossary, https://www.irmi.com/term/insurance-definitions/certificate-of-reinsurance.

notes that "because of the many special cases and exceptions, it is difficult to make correct generalizations about reinsurance."[15] This is particularly true of hybrid agreements.

The IRMI Glossary contains the following two definitions of hybrid reinsurance arrangements:

> **Facultative Automatic** – a form of property and casualty (P&C) reinsurance that is a hybrid between facultative and treaty. A bordereau of risks ceded is submitted to the reinsurer, which has limited rights to decline individual risks.
>
> **Facultative Obligatory Treaty** – the hybrid between the facultative versus treaty approach. It is a treaty under which the primary insurer has the option to cede or not cede individual risks. However, the reinsurer must accept any risks that are ceded.[16]

Guy Carpenter defines **facultative semi-obligatory treaty** as "a reinsurance contract under which the ceding company may or may not cede exposures or risks of a defined class to the reinsurer, which is obligated to accept if ceded."[17] Finally, Patrik describes **non-obligatory agreements** where "either the cedant may not be required to cede or the reinsurer may not be required to assume every single policy of the specified type."[18]

Given the manuscript nature of most reinsurance contracts, it is incumbent on the actuary working with reinsurance to understand the details of these specialized agreements.

Proportional and Non-Proportional Reinsurance

Both treaty reinsurance and facultative reinsurance can be written on either a proportional or non-proportional basis. Proportional reinsurance is intended to provide capacity and surplus relief to ceding companies, while non-proportional reinsurance is intended to provide stability by protecting the risks insured by the ceding company's losses above a limit.

Proportional reinsurance, which is also known as **pro rata reinsurance** and **participating reinsurance**, is given its name because both premiums and losses (payments and liabilities) are shared between the ceding company and the reinsurers based on the cession percentage. With proportional reinsurance, the reinsurer typically pays a **ceding commission** to the ceding company to reimburse for expenses associated with issuing the underlying policy (e.g., acquisition and underwriting expenses). This commission can be reduced if there is uncertainty about the expected profitability of the business.

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[15] Patrik, "Reinsurance," 344.

[16] See IRMI Glossary, https://www.irmi.com/term/insurance-definitions/facultative-automatic and https://www.irmi.com/term/insurance-definitions/facultative-obligatory-treaty.

[17] "Facultative Semi-Obligatory Treaty," Guy Carpenter Glossary, https://www.guycarp.com/content/guycarp/en/home/the-company/media-resources/glossary/f.html.

[18] Patrik, "Reinsurance," 347.

Proportional reinsurance is generally quite easy to administer and offers protection to the ceding company against both the frequency and severity of losses. The two types of proportional reinsurance are quota share and surplus share.

Quota Share Reinsurance

With **quota share reinsurance**, the ceding company cedes to the reinsurer an agreed percentage of each risk it insures (i.e., each subject or underlying policy) that falls within the line(s) of business subject to the reinsurance contract. In return, the reinsurer receives a fixed percentage of premium and losses for all risks ceded to the quota share arrangement.

A simplistic example of quota share reinsurance follows. Assume a quota share reinsurance treaty applicable to a single line of business with a cession percentage of 60% (i.e., the ceding company retains 40% and the reinsurer assumes 60%). Table 1. 1 presents the retained and ceded premium and losses for two underlying policies that are subject to the quota share reinsurance.

Table 1. 1. Quota Share Reinsurance Example

Insured	Gross of Reinsurance		Retained (Net of Reinsurance)		Ceded	
	Earned Premium	Ultimate Loss	Earned Premium	Ultimate Loss	Earned Premium	Ultimate Loss
#1	1,000	600	400	240	600	360
#2	1,000	3,000	400	1,200	600	1,800
Total	2,000	3,600	800	1,440	1,200	2,160

The gross, net of reinsurance, and ceded loss ratios are summarized in Table 1. 2.

Table 1. 2. Quota Share Reinsurance Example (Continued)

Insured	Ultimate Loss Ratio		
	Gross	Net of Reinsurance	Ceded
#1	60%	60%	60%
#2	300%	300%	300%
Total	180%	180%	180%

Observe that with quota share reinsurance, the loss ratios (i.e., the losses divided by the premium) are the same for both the ceding company and the reinsurer.

Variable quota share reinsurance is a special form of quota share reinsurance in which the cession percentage varies based on explicit risk characteristics, such as limit, geography, or type of risk.

Typically, but not always, quota share reinsurance is on a treaty basis. Quota share reinsurance usually applies to the ceding company's net retained account (i.e., after deducting all other reinsurance except perhaps excess of loss catastrophe reinsurance), but practices vary.

Surplus Share Reinsurance

With **surplus share reinsurance**, the ceding reinsurer only reinsures losses that exceed the "surplus" amount after the cedant's retention. The ceding company cedes the surplus amount of risk above its retained line subject to a maximum ceded percentage and limit. In surplus share reinsurance, the **line** describes the amount of the ceding company's retained risk; the reinsurer's share is typically expressed as a multiple of the ceding company's retained line. For example, a three-line surplus share treaty provides reinsurance for three times the ceding company's retained liability, enabling the ceding company to write four times as much insurance as was possible before reinsurance. Continuing with a three-line surplus share reinsurance example, assume the following:

- A ceding company wants to write commercial automobile insurance policies to a maximum limit of 10 million per policy, but its risk appetite framework sets a net retention of 2.5 million per policy.
- A three-line surplus share treaty meets the ceding company's objective by providing 7.5 million surplus share reinsurance.
- Losses arising from policy limits of 2.5 million and lower are retained fully by the ceding company.
- For losses arising from policies with limits greater than 2.5 million, the proportion of each loss covered by the surplus share reinsurance is determined by the formula

Proportion Ceded = [Policy Limit – Retained Line] / [Policy Limit].

Table 1. 3 demonstrates the different proportions ceded based on three different insureds with different policy limits assuming each insured incurs a 2.5 million loss.

Table 1. 3. Surplus Share Reinsurance Example

Insured	Policy Limits(M)	Ultimate Loss (M)	Proportion Ceded	Ultimate Loss (M)	
				Retained	Ceded
#1	2.5	2.5	0%	2.5	0
#2	5	2.5	50% = (5 M – 2.5 M) /5 M	1.25	1.25
#3	10	2.5	75% = (10 M – 2.5 M) /10 M	0.625	1.875

Given the different proportions ceded, surplus share reinsurance can be described as variable quota share reinsurance. In her definition of surplus treaty, Ana J. Mata explains the difference between quota share and surplus share reinsurance:

> The main difference between a surplus treaty and quota share reinsurance (or standard proportional reinsurance) is that in a quota share the insurer and the reinsurer share in a fixed proportion each and every risk of the portfolio (losses and premiums), for example, 80% of every risk may be ceded to the reinsurer. In a surplus treaty, the ceding company retains a fixed maximum amount for each risk and this amount defines the retained proportion depending on the total size of the underlying policy. For example, if the retained line is $100 000 per risk, for a $500 000 policy limit the ceding company retains 20%, while for a $200 000 policy limit it retains 50%.[19]

With surplus share reinsurance, the ceding company limits its net exposure to one line regardless of the amount of insurance written. In practice, there are many variations in how surplus share reinsurance operates, with different numbers of lines that may be in separate reinsurance contracts with different reinsurers.

Functions of Proportional Reinsurance

Of the five primary functions of reinsurance described previously, proportional reinsurance is frequently used to manage capital and solvency margins and to increase capacity. In their 2012 CAS Study Note on reinsurance accounting, Ralph Blanchard and Jim Klann present a detailed example of how a quota share reinsurance contract provides surplus relief, and they comment, "Net leverage ratios [written premium-to-surplus] are significantly improved, although ceded reinsurance leverage ratios are significantly increased. Hence, the insurer's solvency becomes more reliant on its reinsurers' solvency."[20]

Ceding companies often use proportional reinsurance to support their need to write larger risks than they are comfortable with (i.e., increase capacity), and surplus share reinsurance does this most effectively. Depending on the cession percentage and the exposure to event or catastrophic risk, proportional reinsurance can also protect against catastrophes.

Non-Proportional Reinsurance

In non-proportional reinsurance, which is also referred to as excess of loss reinsurance, the reinsurer's response to a loss is determined by the size of the loss. This type of reinsurance is called non-proportional because the premium is not proportional to the limits of coverage. Like proportional reinsurance, non-proportional reinsurance may be written on a treaty or facultative basis.

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[19] Ana J. Mata, "Surplus Treaty," in *Encyclopedia of Actuarial Science* (Wiley Online Library, 2006), https://doi.org/10.1002/9780470012505.tas047.

[20] Ralph S. Blanchard III and Jim Klann, "Basic Reinsurance Accounting – Selected Topics" (CAS Study Note, Arlington, VA, 2012), https://www.casact.org/library/studynotes/Blanchard-Klann-Basic-Rein-Accounting.pdf.

Excess of loss reinsurance describes a form of reinsurance that, subject to a specified limit, indemnifies the ceding company against all or a portion of the amount of loss in excess of the ceding company's retention. The main types of excess of loss reinsurance include the following:

- excess per risk
- excess per occurrence and catastrophe
- annual aggregate excess of loss
- clash.

To understand the differences between these types of reinsurance, it is helpful to focus on the **subject loss**, which are the losses that are relevant to the reinsurance cover.

Excess Per Risk Reinsurance

Excess per risk reinsurance, which is also referred to as **excess per policy reinsurance**, is a form of excess of loss reinsurance that, subject to a specified limit, indemnifies the ceding company against the amount of loss in excess of a specified retention with respect to each risk involved in each loss. A "risk" in this form of reinsurance could be the coverage on one building or a group of buildings for fire or flood or the insurance coverage under a single policy that the ceding company treats as a single risk. Excess per risk insurance is typically less exposed than excess per occurrence and catastrophe reinsurance to accumulations of exposures and losses but can still be impacted by natural catastrophes including earthquakes, wildfires, floods, etc.

An example of excess per risk reinsurance is a ceding company that sells property policies with a 10 million limit and maintains excess per risk reinsurance with a 3 million attachment point and reinsurance limit of 7 million. For a loss of 3 million, the ceding company retains the full loss (i.e., there is no coverage from the excess per risk reinsurance). For a 6.5 million loss, the ceding company retains losses of 3 million, and the reinsurer assumes losses of 3.5 million.

Excess per risk reinsurance is primarily used to protect property exposures, although it can be used for casualty lines of business. Like proportional reinsurance, excess per risk reinsurance enables ceding companies to write larger risks (i.e., increase capacity). While some excess per risk treaties have ceding commissions, the expense and surplus relief tend to be less than proportional reinsurance because the premiums tend to be significantly less.

Excess Per Occurrence Reinsurance and Catastrophe Reinsurance

Excess per risk and excess per occurrence are similar in that the ceding company retains the first portion of loss and the reinsurer assumes the excess of the retention, subject to the reinsurance limit.

Excess per occurrence reinsurance differs from excess per risk as it protects a ceding company from an accumulation of losses due to a single occurrence or event. The subject loss in excess per occurrence reinsurance is the sum of all losses arising from an insured event for all subject policies.

Catastrophe reinsurance, which is also referred to as **catastrophe excess of loss** and **catastrophe cover**, is a form of excess of loss reinsurance that, subject to a specified limit, indemnifies the ceding company for the accumulation of losses in excess of a specified retention arising from a single catastrophic event or a series of events. Catastrophe reinsurance protects against property as well as casualty losses that arise due to natural events (e.g., hurricanes and earthquakes) and man-made events (e.g., terrorist attacks and airplane accidents). Catastrophe reinsurance is offered on a worldwide basis as well as in limited regions.

In the event of a loss, which may be a full limit loss or other amount (e.g., 50% of limit) that is specified in the reinsurance contract, most catastrophe reinsurance contracts provide for a reinstatement of the policy limit. A **reinstatement** is the restoration of the policy limit following payment of a full limit loss. One or more reinstatements may be automatic as part of the reinsurance terms or may be available on request. Depending on the terms, the reinstatement may be included with or without additional premium. Premium paid for a reinstatement is referred to as **reinstatement premium**.

It is important for the actuary to track reinstatement premiums separately, as the accounting treatment of reinstatement premiums may differ from other reinsurance premium in that reinstatement premium may be considered earned immediately. Furthermore, reinstatement premium can distort historical relationships between premium and losses and should be recognized in the determination of expected loss ratios, which are critical assumptions for some loss projection techniques.

An example of catastrophe reinsurance is a ceding company that maintains catastrophe reinsurance of 35 million. Assume a flood results in total personal property and commercial property losses of 42 million. The ceding company would retain losses of 35 million, and the reinsurer would assume losses of 7 million.

Example of Excess Per Risk and Catastrophe Reinsurance

It is critically important to understand how multiple reinsurance contracts, both treaty and facultative, interact. In reinsurance, one refers to how a contract inures to the benefit of another. Guy Carpenter's Glossary of Reinsurance Terms defines **inure to the benefit of** as follows:

> To take effect for the benefit of either the reinsurer or the reinsured. With respect to a given reinsurance contract (usually treaty), other reinsurances which are first applied to reduce the loss subject to the given contract are said to inure to the benefit of the reinsurer of that given contract. If the other reinsurances are to be disregarded as respects loss to the given contract, they are said to inure to the benefit of the reinsured.[21]

[21] "Inure to the Benefit of," Guy Carpenter Glossary, https://www.guycarp.com/content/guycarp/en/home/the-company/media-resources/glossary/i.html.

An example helps clarify the application of excess per risk reinsurance and catastrophe reinsurance as well as how one contract inures to the benefit of another contract. Assume a ceding company writes 200 personal property policies each with a 2 million limit. Further, assume that the ceding company purchases excess per risk reinsurance with a retention of 1 million and reinsurance policy limit of 1 million. The ceding company also purchases catastrophe reinsurance with a retention of 20 million and reinsurance policy limit of 150 million. The per risk excess reinsurance inures to the benefit of the catastrophe reinsurance. After a major wildfire, the ceding company's total insured losses (prior to any reinsurance) and the losses ceded to the per risk reinsurance are summarized in Table 1. 4

Table 1. 4. Excess Per Risk Reinsurance Example

Individual Losses Expressed as Proportion of 2 Million Policy Limits	Individual Losses Per Policy	# Insureds Suffering Losses	Total Insured Losses	Losses Ceded Excess Per Risk Reinsurance
10%	200,000	35	7 million	0
50%	1 million	10	10 million	0
100%	2 million	5	10 million	5 million

The ceding company's retained losses after the excess per risk reinsurance are 22 million, and the catastrophe reinsurance then applies with a cession of 2 million (22 million minus retention of 20 million). Recall that the ceding company's net retention is 20 million.

The situation would be quite different if all 200 homes were totally destroyed by the wildfire, which is a highly unlikely situation. Nevertheless, the losses for such an event would be as follows:

- Total insured losses of 400 million (200 insureds x 2 million policy limits).
- Total losses ceded to excess per risk of 200 million (200 insureds x 1 million excess per risk policy limits).
- Total losses ceded to catastrophe reinsurance of 150 million.
- Total losses retained by ceding company of 50 million, which are equal to
    - 20 million retention of catastrophe reinsurance, and
    - 30 million of losses above the 150 million policy limit of the catastrophe reinsurance.

If the ceding company were to incur a full limit loss under the catastrophe reinsurance, reinstatement of the policy limit could be very important, especially if the losses were to occur when there is significant time remaining in the contract period.

Annual Aggregate Excess of Loss Reinsurance

Aggregate excess of loss reinsurance, which is also referred to as **aggregate stop-loss reinsurance**, is a form of excess of loss reinsurance that provides the ceding company with a guarantee that their losses will not exceed a predetermined threshold, which can be specified as a percentage of premiums (i.e., loss ratio) or a fixed dollar amount. The reinsurer indemnifies the ceding company for the amount of losses that are greater than a specified aggregate value.

For example, assume a captive insurer writing medical malpractice coverage seeks aggregate excess of loss reinsurance. Alternatives for the aggregate excess of loss reinsurance coverage could include:

- 20% loss ratio excess of the captive's retention of a 90% loss ratio, and
- 10 million limits excess of the captive's retention of 50 million.

Continuing this example, assume the aggregate excess of loss reinsurance is stated in terms of loss ratio and that the captive has subject premium of 10 million. Thus, the aggregate excess of loss reinsurance would provide coverage of 2 million (10 million premium x 20%) excess of 9 million losses (10 million premium x 90%).

Aggregate excess of loss reinsurance generally applies to all or part of the ceding company's net retention and protects net results (i.e., other reinsurance inures to the benefit of the aggregate excess of loss reinsurance), although claims occurring from natural catastrophes may be excluded or have per occurrence limits. For a ceding company seeking to protect its capital, aggregate excess of loss reinsurance best achieves this objective. However, this type of reinsurance is often unavailable and, when available, can be very expensive.

Clash

Clash reinsurance is a casualty reinsurance contract that attaches above all other policy limits. IRMI describes clash coverage as a type of reinsurance that protects a ceding company "from the loss of its normal reinsurance recoveries when it is faced with multiple claims from multiple insureds arising out of the same catastrophe and where its reinsurance does not fully reimburse the insurer for these related losses."[22] The objective of clash coverage is to protect the ceding company burdened by multiple claims arising from exceptional events that are beyond the types of claims contemplated by traditional primary insurance and excess of loss reinsurance policies.

The definition of clash event is a critical aspect of a clash reinsurance contract and varies according to the intentions of the insurer and reinsurer. IRMI notes that the core definition of clash event generally has three components:

[22] Larry Schiffer, "Clash Cover Reinsurance and Economic Catastrophe Losses," IRMI Expert Commentary, March 2009, https://www.irmi.com/articles/expert-commentary/clash-cover-reinsurance-and-economic-cat-losses.

- The loss must arise out of multiple policies held by one insured or similar policies held by multiple insureds.
- All damages are traceable to and the direct consequence of a specific event.
- The event must take place in its entirety within a specific timeframe.[23]

Finite Risk Reinsurance

The Insurance Information Institute describes **finite risk reinsurance** as "a form of reinsurance that specifically incorporates the time value of money. Unlike most reinsurance contracts, finite risk contracts are usually multi-year. In other words, they spread risk over time and generally take into account the investment income generated over the period."[24]

Finite reinsurance products typically have the following features:

- Risk transfer and risk financing combined in a multi-year contract.
- Emphasis on the time value of money, with investment income explicitly included in the contract.
- Limited assumption of risk by the reinsurer.
- Sharing of the results with the ceding company.[25]

The Insurance Information Institute uses the term **run-off** to refer to a special segment of solutions and products focused on the full-scale transfer of reserve development risks. They state:

> Run-off solutions are tools that address a firm's earnings volatility arising from past activities. There are a number of special situations that motivate a company to choose a run-off option, like corporate restructuring, mergers & acquisitions, discontinuation of lines of business, erratic changes in the valuation or cost of a liability, or regulatory, accounting or tax changes. The biggest run-off transactions to date in the United States have involved either asbestos & environmental (A&E) or workers' compensation liabilities. Most transactions have involved insurers, but the economics also work for corporations and captives.[26]

Loss Portfolio Transfers

While most primary P&C insurance contracts are written for a one-year policy term, losses frequently pay out over many years. As a result, insurers hold large loss reserves that are associated with payments in future years for policies written in prior years. At times, insurers want to be relieved of the uncertainty associated with such loss reserves and relief in the capital that must be held for these

[23] Schiffer, "Clash Cover Reinsurance."

[24] "Finite Risk Reinsurance," Insurance Information Institute, https://www.iii.org/article/finite-risk-reinsurance.

[25] "Finite Risk Reinsurance," https://www.iii.org/article/finite-risk-reinsurance.

[26] "Finite Risk Reinsurance," https://www.iii.org/article/finite-risk-reinsurance.

reserves. A **loss portfolio transfer** (LPT) is a form of reinsurance that transfers, at a specified accounting date, from the ceding company to the reinsurer all or a portion of the liability for future loss payments. The IRMI Glossary provides the following definition of an LPT:

> A financial reinsurance transaction in which loss obligations that are already incurred and will ultimately be paid are ceded to a reinsurer. In determining the premium paid to the reinsurer, the time value of money is considered, and the premium is therefore less than the ultimate amount expected to be paid. The cedent's statutory surplus increases by the difference between the premium and the amount that had been reserved. An insurer seeking to withdraw from writing workers' compensation coverage in a given state could, for example, use a loss portfolio transfer to meet its obligations under policies it has written, without the need to continue the day-to-day management of the claims resolution function.[27]

Typically, LPTs are used with long-tail lines of business (such as medical malpractice, asbestos, and pollution liability) where there are significant delays in the reporting of claims and the losses may not be settled for years. Timing is the main element of risk. If claims are settled earlier than expected, then investment income could be lower than anticipated, and the reinsurer could lose money on the contract. In an LPT, the ultimate total nominal losses are usually limited by the finite reinsurance contract.

Adverse Development Cover

An alternative to an LPT is **adverse loss development cover** (or simply **adverse development cover**), where the ceding company receives reimbursement from the reinsurer for losses in excess of a pre-agreed retention level. Unlike an LPT, there is no transfer of loss reserves from the ceding company to the reinsurer providing the adverse loss development cover. Instead, reinsurance is set at the level of the reserves held or at some higher level (often expressed as a multiple) of the held reserves. A key use of adverse development cover is mergers and acquisitions where the ceding company can transfer risks associated with both timing and adverse reserve development.

Reinsurance Concepts and Contract Provisions Influencing the Estimation of Unpaid Losses

Losses-Occurring-During and Risks-Attaching

Given the tailor-made nature of reinsurance contracts, it is critically important that the contract wording appropriately reflects the intent of the parties and that the ceding company and reinsurer fully understand what risks are being reinsured. The **business-covered clause**[28] describes "whether the reinsurance contract is covering risks or policies written by the reinsured that attach to the reinsurance

[27] "Loss Portfolio Transfer (LPT)," IRMI Glossary, https://www.irmi.com/term/insurance-definitions/loss-portfolio-transfer.

[28] This clause is also known as the reinsuring clause, cover clause, business reinsured clause, or the application of agreement clause.

contract or whether losses on policies issued by the reinsured occurring during the life of the reinsurance contract are being reinsured."[29]

There are two primary approaches of reinsurance coverage: losses-occurring-during and risks-attaching (also known as policies-attaching). Losses-occurring-during contracts provide reinsurance coverage for all losses that occur between the contract inception and expiration dates regardless of when the ceding company issued the underlying policy that resulted in the loss. Risks-attaching contracts provide reinsurance coverage only for those policies that incepted during the reinsurance contract effective period; the underlying policies that are covered by risks-attaching reinsurance can have a policy expiration that is later than the expiration date of the reinsurance contract.

For example, assume a ceding company has a property per risk excess of loss reinsurance contract with an attachment point of 2 million and policy limits of 10 million. Further assume that the reinsurance contract is losses-occurring-during with an inception date of January 1, 2020 and expiration date of December 31, 2020.

- A 3 million fire loss that occurred on February 15, 2020 arising from an underlying policy with effective dates of July 1, 2019 to June 30, 2020 would have reinsurance coverage of 1 million (i.e., 3 million total loss less 2 million retention of the ceding company) because the occurrence date of the loss is within the effective period of the reinsurance contract.
- Similarly, a 3 million fire loss that occurred on February 15, 2020 arising from an underlying policy with effective dates of February 1, 2020 to January 31, 2021 would have reinsurance coverage of 1 million.
- A 3 million fire loss that occurred on February 15, 2021 arising from an underlying policy with effective dates of July 1, 2020 to June 30, 2021 would not have reinsurance coverage, because the date of loss (i.e., February 15, 2021) is after the reinsurance contract expiry date of December 31, 2020. This assumes that the reinsurance contract was not renewed or replaced with other applicable coverage.

Next, assume a ceding company has a liability quota share risks-attaching contract with a 60% ceding percentage (i.e., the reinsurer assumes 60% of premium and losses). Further assume that the inception date of the contract is July 1, 2020 and the expiration date is June 30, 2021.

- A 2 million liability loss that occurred on February 15, 2021 arising from an underlying policy with effective dates of June 1, 2020 to May 31, 2021 would not have reinsurance coverage because the underlying policy began before the inception date of the reinsurance contract (i.e., July 1, 2020).

[29] Larry Schiffer, "Understanding the Business-Covered Clause in a Reinsurance Contract," IRMI Expert Commentary, November 2003, https://www.irmi.com/articles/expert-commentary/understanding-the-business-covered-clause.

- A 2 million liability loss that occurred on February 15, 2021 arising from an underlying policy with effective dates of July 15, 2020 to July 14, 2021 would have reinsurance coverage because the inception date of the underlying policy is within the reinsurance contract effective dates.
- A 2 million liability loss that occurred on August 15, 2021 arising from an underlying policy with effective dates of September 1, 2020 to August 31, 2021 would have reinsurance coverage because the underlying policy incepted during the reinsurance contract period even though the loss occurred after the expiry of the reinsurance contract period.

While losses-occurring-during and risks-attaching are the two most common types of reinsurance contracts, coverage can be tailored to meet unique circumstances of the parties to the contract. Thus, it is incumbent on the actuary to understand details of the contract provisions.

Subscription Percentage

Some reinsurance placements are shared by multiple reinsurers through subscription policies. In the context of reinsurance, a **subscription policy** is a reinsurance policy in which multiple reinsurers share the risk associated with providing the reinsurance coverage. Subscriptions can be used when the amount of coverage is more than any one reinsurer is willing to assume and when the primary insurer is seeking to diversify its risk, particularly credit risk. For losses subject to reinsurance placed with multiple reinsurers, it is important that the actuary be aware of the percentage subscribed, as there can be situations in which the full coverage is not placed, and thus the primary insurer would bear responsibility for losses that had been intended for reinsurance.

Commutation Clause

Commutation refers to the cancellation or dissolution of a reinsurance contract. With a commutation, the reinsurer pays funds (at present value) that are not yet due to the ceding company in exchange for full termination of all future obligations related to the reinsurance contract.

Some reinsurance contracts contain a **commutation clause**, also known as a **commutation agreement**, that sets out the terms and conditions for the estimation, payment, and complete discharge of all obligations of the parties to a reinsurance contract. This clause is common in reinsurance contracts covering U.S. workers' compensation and can be optional or mandatory.

Ceding companies use commutations for many reasons. For example, a ceding company may commute a reinsurance contract because it wants to:

- Exit a line of business or geographic region.
- Manage reserves for transfer or sale.
- Avoid the credit risk associated with its reinsurer, particularly if the reinsurer has suffered a ratings downgrade.
- Better manage claims and claims-related expenses and believes that its own staff has the expertise required.

Similarly, reinsurers use commutations for a variety of reasons. For example, a reinsurer may commute a reinsurance contract because it wants to

- Terminate a relationship with a ceding company that is in run-off or one with which it no longer conducts business.
- Protect itself from the potential insolvency of a ceding company.
- Avoid disputes when there are significant differences of opinion with respect to future loss development of subject losses.

Understanding commutations is important for the actuary estimating unpaid losses for several reasons. First, actuaries are frequently involved in the analysis of reinsurance contracts that are subject to commutation. Second, an actuary at a ceding company must be aware of contracts that are commuted, as such affects the estimation of unpaid ceded losses. Similarly, an actuary at a reinsurer must be aware of contracts that are commuted as there is no longer liability associated with such contracts. Finally, actuaries working for both primary insurers and reinsurers should track commuted reinsurance contracts, as the loss development patterns for such contracts could be different from other contracts that remain in force. Thus, actuaries frequently choose to exclude commuted contracts from historical data.

Conclusion

This text is meant to serve as an introduction to reinsurance with a focus on basic reserving methodologies. Reinsurance, which is foundational to a sound global insurance market, can be exceptionally complex. This text is not intended to address these complexities – neither those seen in the commercial market between insurers and reinsurers nor those used within an insurance group through the use of internal reinsurance agreements. Similarly, it is not intended to describe the sophisticated reinsurance arrangements that are frequently created by combining different types of reinsurance with manuscript terms and conditions. Examples and descriptions of complex reinsurance towers can be found readily through internet searches. Instead, the objective is to provide a foundation for the actuary that aids in further study as well as experience working with reinsurance.

Chapter 2 – Data Requirements

This chapter is organized as follows:

- Introduction
- Sufficient and Reliable Data
- Homogeneity and Credibility of Data
- Organization of Data by Experience Period
- Knowledge of Reinsurance Terms and Conditions
- Types of Data
- Sources of Data

Introduction

In *Actuarial Standards of Practice* (ASOP) *23–Data Quality*, the U.S. Actuarial Standards Board (ASB-US) defines data as: "numerical, census, or classification information, or information derived mathematically from such items, but not general or qualitative information. Assumptions are not data, but data are commonly used in the development of actuarial assumptions." [30] The *International Actuarial Standard of Practice (ISAP) Glossary* has a slightly different definition of data and states that data "are usually quantitative but may be qualitative."[31]

Many considerations related to data (quantitative and qualitative) are similar for actuaries working with insurers and those working with reinsurers. Actuaries seek data that are sufficient and reliable. They strive to aggregate data in segments that are homogeneous and credible. They organize data by experience periods that best meet their needs from operational as well as user perspectives. There are important differences, however, in each of these areas as well as in the types and sources of data used by actuaries working in primary insurance versus reinsurance. Many of these issues are explored in this chapter.

Sufficient and Reliable Data

The requirements for sufficient and reliable data for actuarial work are typically set out in actuarial standards of practice. The Canadian actuarial standards of practice describe sufficient and reliable data

[30] ASB-US, *ASOP 23* (revised edition, December 2016), section 2.3, http://www.actuarialstandardsboard.org/wp-content/uploads/2017/01/asop023_185.pdf.

[31] International Actuarial Association, *ISAP Glossary* (November 2019), 2, https://www.actuaries.org/iaa/IAA/Publications/ISAPs/IAA/Publications/05ISAPs.aspx.

as follows: "Data are sufficient if they include the needed information for the work ... Data are reliable if they are sufficiently complete, consistent, and accurate for the purposes of the work."[32]

The International Actuarial Association's *ISAP 1 – General Actuarial Practice* has similar descriptions. *ASOP 23* uses the term appropriate data and defines the term as: "Data suitable for the intended purpose of an analysis and relevant to the system or process being analyzed."[33]

Sufficiency

To determine if data are sufficient for the estimation of unpaid losses, it is helpful to review the key assumptions of the development method, which is one of the most common methods used to project ultimate values. Key assumptions of the development method include the following:

- Losses recorded to date (reported or paid) will continue to develop in a similar manner in the future.
- The relative change in a given year's losses from one evaluation point to the next is similar to the relative change in prior years' losses at similar evaluation points.
- For an immature year, the losses observed to date are valuable for projecting the losses yet to be observed.
- Throughout the experience period, there has been consistency in the mix of business, attachment points and policy limits, and claim processing (which includes the reporting, establishment of case estimates, and settlement of claims).

Ensuring the sufficiency of data can be particularly challenging for actuaries working with reinsurers due in large part to the manuscript nature of many reinsurance contracts, where terms can differ from one ceding company to the next and can change from year to year. Furthermore, operational and strategic changes that were implemented at the ceding companies, the reinsurer, or both can lead to violation of the assumption of consistency in the mix of business, attachment points and limits, and claims processing.

Reliability

With respect to the accuracy of data, the actuary has an obligation to validate the data. *ISAP 1* sets out the following requirements for data validation:

> Data Validation – The actuary should take reasonable steps to review the consistency, completeness, and accuracy of the data used. These might include:

[32] Canadian Institute of Actuaries, *Standards of Practice* (January 2020), Section 1440.04 and .05, https://www.cia-ica.ca/publications/standards-of-practice.

[33] *ASOP 23*, section 2.1.

a. Undertaking reconciliations against audited financial statements, trial balances, or other relevant records, if these are available;
b. Testing the data for reasonableness against external or independent data;
c. Testing the data for internal consistency and consistency with other relevant information; and
d. Comparing the data to those for a prior period or periods.

The actuary should describe this review in any report.[34]

ASOP 23 sets out the following requirements for the review of data:

> A review of data may not always reveal defects. Nevertheless, the actuary should perform a review, unless, in the actuary's professional judgment, such review is not necessary or not practical. In exercising such professional judgment, the actuary should take into account the purpose and nature of the assignment, any relevant constraints, and the extent of any known checking, verification, or audit of the data that has already been performed.[35]

ASOP 23 describes the requirements for the actuary to make a reasonable effort to determine the definition of each data element used in the analysis, to identify questionable data values, and to review prior data.

Actuaries working for reinsurers can face more challenges than those working with primary insurers in the validation of data due to the following:

- For each ceding company and broker reporting on behalf of a ceding company, different it systems that capture different types of data and use different terminology for similar types of data.
- Use of bordereau reporting that can differ (by ceding company and broker) in the types of data reported, the labeling of such data, and the frequency of submission to the reinsurer.
- Lags in reporting related to:
    - The inherent delay in claims that must first be reported to the ceding company before they are reported to the reinsurer;
    - The long-tailed nature of certain types of reinsurance such as excess per risk (where it takes time to know that a specific claim has breached the ceding company's retention) and catastrophe reinsurance (where it can take time before aggregated losses exceed the ceding company's retention); and

[34] International Actuarial Association, *ISAP 1* (December 2018), section 2.5.2, https://www.actuaries.org/iaa/IAA/Publications/ISAPs/IAA/Publications/05ISAPs.aspx.

[35] *ASOP 23*, section 3.3.

    - Bordereau reporting, where losses are only reported on a quarterly or more infrequent basis.
- Gaps in reporting critical information from the ceding companies about claims (including loss payments and case reserves) and claims-management expenses (e.g., investigation, legal, and expert witness expenses).
- Manuscript nature of reinsurance policies that can lead to different coverage for similar loss events with different ceding companies.
- Issues related to data coding for the reinsurer itself.

Nevertheless, the obligations related to using reliable data and validating data that stem from professionalism requirements as well as insurance law and regulation are equally applicable to actuaries working with reinsurers as primary insurers.

Homogeneity and Credibility of Data

Considerations related to the homogeneity and credibility of data are important for all actuaries estimating unpaid losses.

Homogeneity

The term **homogeneous risk group** (**HRG**) used in the European Union's Solvency II Directive is helpful in explaining the key characteristics that underlie the actuary's segmentation of data. HRG is described as:

> Set of (re)insurance obligations which are managed together and which have similar risk characteristics in terms of, for example, underwriting policy, claims settlement patterns, risk profile of policyholders, likely policyholder behaviour, product features (including guarantees), future management actions and expense structure. The risks in each group should be sufficiently similar to allow for a reliable valuation of technical provisions[36] (including a meaningful statistical analysis). The classification is undertaking-specific.[37]

The goal in segmenting data is to improve the robustness of the estimates of unpaid losses by subdividing experience into groups that exhibit similar characteristics. As a result, when separating data into groups for an analysis of unpaid losses, actuaries working for primary insurers and reinsurers focus on similar considerations, such as

[36] The term **technical provisions** is used widely outside of the U.S. and Canada. Technical provisions is defined in the International Association of Insurance Supervisors' Glossary as: "The amount that an insurer sets aside to fulfil its insurance obligations and settle all commitments to policyholders and other beneficiaries arising over the lifetime of the portfolio, including the expenses of administering the policies, reinsurance and of the capital required to cover the remaining risks." (see https://www.iaisweb.org/page/supervisory-material/glossary).

[37] Committee of European Insurance and Occupational Pensions Supervisors (CEIOPS), *CEIOPS' Advice for Level 2 Implementing Measures on Solvency II: Technical Provisions – Lines of Business on the Basis of which (Re)Insurance Obligations Are to Be Segmented* (October 2009), section 3.6, https://register.eiopa.europa.eu/CEIOPS-Archive/Documents/Advices/CEIOPS-L2-Final-Advice-Technical-Provisions-Segmentation.pdf.

- Consistency of the coverage triggered by the losses in the group.
- Length of time to report the claim once an insured event has occurred (i.e., reporting patterns).
- Ability to develop an appropriate case outstanding estimate from earliest report through the life of the claim.
- Length of time to settle the claim once it is reported (i.e., settlement, or payment, patterns).
- Likelihood of claim to reopen once it is settled.
- Average settlement value (i.e., severity).
- Volume of losses in the group.

Actuaries strive to determine HRGs in which the claims display similar traits with respect to these characteristics.

Credibility

The goal for the actuary is to divide the data into sufficiently homogeneous risk groups without compromising credibility. The ASB-US's *ASOP 25–Credibility Procedures* defines credibility as: "A measure of the predictive value in a given application that the actuary attaches to a particular set of data (predictive is used here in the statistical sense and not in the sense of predicting the future)."[38] Increasing the homogeneity of the group of data and increasing the volume of data in the group tend to increase credibility. If, however, the actuary divides the data into too many homogeneous groupings, there is a risk that the volume of data in the individual groups becomes insufficient to perform a reliable analysis.

Differences in Considerations Related to Homogeneity and Credibility for Reinsurance versus Insurance

While many of the considerations are similar for actuaries working with primary insurance and reinsurance, there are some important differences. In particular, there are notable differences in how actuaries working with primary insurance and reinsurance segment data. For example, actuaries working with primary insurance frequently aggregate data by line or sub-line of business, as claims within such lines are typically subject to the same or similar laws, policy terms, claims-management expense, etc. For reinsurance, however, there can be important differences within a line of business based on the type of reinsurance contract (e.g., treaty versus facultative and proportional versus non-proportional) that require further segmentation.

Using auto insurance as an example to differentiate reinsurance from primary insurance, an actuary working with a large insurer may have a sufficient volume of credible experience to segment data by the following:

[38] ASB-US, *ASOP 25* (revised edition, December 2013), section 2.1, http://www.actuarialstandardsboard.org/wp-content/uploads/2014/02/asop025_174.pdf.

- Personal lines auto separate from commercial lines auto;
- Jurisdiction (e.g., state, province, or region); and
- Sub-coverage, including:
    - Third-party liability, which may be further separated for bodily injury (BI) and property damage (PD);
    - No-fault benefits (known as personal injury protection, or PIP, in the United States and accident benefits, or AB, in Canada), which may be further separated for various types of benefits including medical and rehabilitation, disability income, funeral, etc.; and
    - Physical damage, which may be further separated for type of coverage, such as collision and comprehensive.

In contrast, an actuary working with a large reinsurer may segment auto reinsurance data by:

- Personal lines auto separate from commercial lines auto.
- Treaty separate from facultative.
- Pro rata separate from excess.
- Aggregate stop-loss and finite risk covers separate from all other segments.

One notable difference with the segmentation for reinsurers when compared to primary insurers is that losses are generally not segmented at a sub-coverage level or jurisdiction level, although a global reinsurer would likely segment data by country or region. Furthermore, a reinsurer may segment excess of loss per risk and excess of loss per occurrence at various attachment points, where a primary insurer may segment losses at alternative limits (e.g., losses limited to 1 million, losses limited to 2.5 million, etc.).

In his chapter on reinsurance, Patrik discusses partitioning the reinsurance portfolio into reasonably homogeneous exposure groups that are relatively consistent over time with respect to the mix of business. For partitioning a reinsurance portfolio, he provides a list of the important variables that affect the pattern of claim report lags to the reinsurer and the development of individual case amounts. Patrik's priority-ordered list includes:

- Line of business (property, casualty, bonding, ocean marine, etc.);
- Type of contract (facultative, treaty, finite or financial);
- Type of reinsurance cover (quota share, surplus share, excess per risk, excess per occurrence, aggregate excess, catastrophe, loss portfolio transfer, etc.);
- Primary line of business for casualty;
- Attachment point for casualty;
- Contract terms (flat-rated, retro-rated, sunset clause, share of loss adjustment expense, claims-made or occurrence coverage, etc.);
- Type of ceding company (small, large, or excess and surplus; and

- Intermediary (i.e., broker).[39]

Patrik notes that it is likely not possible to separate data by all of the above criteria, as the resulting segments would lack sufficient volume to produce credible results. A critical factor in determining how to segment data is related to the credibility of the data. Noting that there is no "typical reinsurer," he nevertheless provides the following example of segmentation for a reinsurer:

- Treaty casualty excess
- Treaty casualty proportional
- Treaty property excess
- Treaty property proportional
- Treaty property catastrophe
- Facultative casualty
- Facultative property
- Surety
- Fidelity
- Ocean marine
- Inland marine
- Construction risks
- Aviation
- Finite or nontraditional reinsurance
- Miscellaneous special contracts, pools, and associations
- Asbestos, pollution, and other health hazard or mass tort claims[40]

A large global reinsurer may further segregate some of the above groups by major region such as Americas, Europe, Asia, and rest of world.

Another consideration regarding the homogeneity and the grouping of data relates to changes in the portfolio. In some circumstances, it may be appropriate to combine data from treaty and facultative reinsurance even if these types of reinsurance typically exhibit different underlying loss patterns. However, if the relative volume of business is changing between these two types of reinsurance and underlying development patterns differ, then the grouping may not be appropriate. *Estimating Unpaid Claims Using Basic Techniques* contains a detailed example of the effect on various projection techniques of analyzing a portfolio where the growth of personal automobile and commercial automobile differ, and the consequence of the changing proportions on the various estimation techniques is significant.

[39] Patrik, "Reinsurance," 443.

[40] Patrik, "Reinsurance," 444.

Organization of Data by Experience Period

For estimating unpaid losses, reinsurers typically rely on aggregation by accident year or underwriting year. Underwriting year is also referred to as treaty year and contract year. In this text, the terms underwriting year and treaty year are used interchangeably.

The requirements for financial reporting as well as internal management reporting and planning are important considerations for selecting an approach to aggregating data. For example, reinsurers operating in the United States and Canada require accident year results for statutory financial reporting. That said, reinsurers may analyze data by treaty year and then use allocation approaches to derive accident year results for statutory financial reporting purposes.

Accident Year Aggregation

Accident year data refer to losses grouped according to the date of occurrence (i.e., the accident date or the coverage triggering event). For example, accident year 2020 consists of all losses with an occurrence date in 2020. Aggregation by accident year is the most common grouping of loss data for the actuarial analysis of unpaid losses for primary insurers. Accident year aggregation is also used extensively by many reinsurers in the United States and Canada because of financial and statistical reporting requirements.

Calendar year earned premiums are used to provide an approximate matching of the losses that occur during the year with the insurance premiums earned by an insurer during the year in which the insurance coverage is effective.

Accident year aggregation has become the accepted norm for P&C insurers (including reinsurers) in the United States and Canada. Accident year grouping is easy to achieve and easy to understand. It represents losses occurring over a shorter time frame than for underwriting year aggregation, implying that ultimate accident year losses should become reliably estimable sooner than those for an underwriting year. Industry benchmarks, including data from the Reinsurance Association of America (RAA) and AM Best, are based on accident year experience. Finally, tracking losses by accident year is valuable when there are changes due to economic or regulatory forces (such as inflation or law amendments) or major loss events (such as atypical weather or a major catastrophe) that can influence loss experience.

A significant disadvantage of accident year aggregation is the potential mismatch between losses and premiums. Accident year aggregation includes losses from policies underwritten and priced at more varied times than underwriting year aggregation.

Underwriting (Treaty) Year Aggregation

Underwriting year data, which is frequently used by European reinsurers and Lloyds of London, refer to losses grouped by the year in which the reinsurance policy became effective (i.e., the year in which the

contract was incepted). Underwriting year for reinsurance is similar conceptually to policy year for primary insurance.

Losses arising from an underwriting year can extend over many calendar years. For example, if the reinsurance contract is for a 12-month duration and on a risks-attaching basis, the losses arising from such an underwriting year can extend over three calendar years. Continuing this example, underwriting treaty year 2020 for a reinsurer writing proportional risks-attaching reinsurance contracts refers to all reinsurance policies with beginning effective dates between January 1, 2020 and December 31, 2020. For annual reinsurance policies with a January 1, 2020 effective date, covered policies will have effective dates between January 1, 2020 and December 31, 2020 and thus accident dates between January 1, 2020 and December 30, 2021. For annual reinsurance policies with a December 31, 2020 effective date, covered policies will have effective dates between December 31, 2020 and December 30, 2021 and thus accident dates between December 31, 2020 and December 29, 2022. Thus, for this example, treaty year 2020 includes losses arising from three calendar years.

The primary advantage of underwriting year aggregation is a true match between losses and premiums. Underwriting year experience can be important when underwriting or pricing changes occur, such as

- A shift in attachment points or limits.
- A new emphasis on certain classes of business or regions.
- A change in the types of ceding company.
- An increase or decrease in the price.

All of the above can lead to a significant change in expected loss ratios, and many of the above can lead to changes in loss development patterns.

The primary disadvantage of underwriting year aggregation is the extended time frame. As seen in our previous example, an underwriting year can extend over a 36-month period, generally resulting in a longer time until all the losses are reported and a longer time until the ultimate losses can be reliably estimated. This disadvantage can present challenges in the projection of ultimate losses for the most immature underwriting years where cumulative development factors are highly leveraged and the written premium is not fully earned. (Chapter 3 includes examples of possible solutions to these challenges.) Underwriting year data can also make it difficult to understand and isolate the effect of a single large event such as a major court ruling that changes how insurance contracts are interpreted.

Allocation to Accident Year from Underwriting Year

Reinsurers often use underwriting year aggregation for the development of best estimates of ultimate losses and unpaid losses and rely on accident year aggregation for financial reporting and to track how ultimate losses (i.e., reported losses plus incurred but not reported, IBNR, losses) develop over time.

Actuaries who conduct their analysis of unpaid losses using data aggregated by treaty year may need to allocate results to accident year for financial reporting or other purposes. Allocation processes are typically based on how premium is earned over the contract period.

When the reinsurer receives from the ceding company (or broker) detailed loss data including key dates (such as date of loss and policy effective date), then accurate assignment to accident year or underwriting year can occur. However, there are times, particularly for treaty proportional reinsurance, when such details are not available to the reinsurer. In such situations, the reinsurer would typically use earnings profiles to allocate estimates of unpaid losses to accident year. (See Chapter 3 for a detailed example of earning premium.)

Knowledge of Reinsurance Terms and Conditions

It is critically important that actuaries understand the key terms and conditions of reinsurance programs. This is true for actuaries working with reinsurers and those working with primary insurers with responsibility for estimating the ultimate losses and unpaid losses ceded to reinsurers. For example, actuaries need to know the following:

- Business covered, exclusions, and limitations.
- Ceding percentage for quota share reinsurance.
- Retention (i.e., first line) and number of lines for surplus share reinsurance.
- Retention and limits for excess of loss reinsurance and whether excess insurance is per risk or per occurrence.
- Attachment point and limits for stop-loss reinsurance.
- Treatment of loss adjustment expenses and recoveries (such as salvage and subrogation).

It is common for reinsurance terms and conditions, including ceding percentages and retentions, to change from time to time. Thus, it is the actuary's responsibility to maintain documentation of historical terms as well as be familiar with current terms. Actuaries work closely with underwriters and claims professionals to ensure knowledge of qualitative information that can influence the estimation of unpaid losses.

Types of Data

Actuaries working with reinsurers typically rely on paid losses, case reserves, and reported losses (i.e., the sum of paid losses and case reserves) as well as written and earned premiums. Case reserves often include the case reserves set by the primary insurer as well as **additional case reserves** (ACR) that are set by the reinsurer. Unlike actuaries working with primary insurers, actuaries working with reinsurers usually do not have access to detailed claim count data nor earned exposure information, such as the number of insured vehicles for auto insurance or number of insured properties for homeowners insurance.

The absence of claim count and exposure data leads to far fewer options for triangle-based diagnostics, as the actuary is not able to calculate triangles of average claim values (e.g., average paid, average case outstanding, and average reported) nor count-based ratio triangles (e.g., ratios of closed-to-reported counts and closed with pay-to-closed counts). Thus, the actuary should turn to other types of investigation, particularly interviews with management of the reinsurer and ceding companies to understand the environment and any changes therein. Chapter 4 of *Estimating Unpaid Claims Using Basic Techniques* includes significant detail about meetings with management to understand the environment and includes sample questions for interviews with senior leaders and the underwriting, claims, data processing, and pricing departments.

Bordereau Reporting

Reinsurers often receive data from ceding companies by **bordereaux**, which Robert W. Strain defined as:

> Furnished periodically by the reinsured, a detailed report of insurance premiums or losses affected by reinsurance. A premium bordereau contains a detailed list of policies (or bonds) reinsured under a reinsurance treaty during the reporting period, reflecting such information as the name and address of the primary insured, the amount and location of the risk, the effective and termination dates of the primary insurance, the amount reinsured and the reinsurance premium applicable thereto. A loss bordereau contains a detailed list of claims and outstanding expenses and paid by the reinsured during the reporting period, reflecting the amount of reinsurance indemnity applicable thereto. Bordereau reporting is primarily applicable to pro rata reinsurance arrangements and to a large extent has been supplanted by summary reporting.[41]

There are numerous challenges associated with bordereau reporting, including how data are cumulated by the ceding company or the broker and absorbed by the reinsurer. There are also issues related to the frequency with which reinsurers receive bordereaux. Bordereaux can be submitted by ceding companies or brokers on a monthly, quarterly, semi-annual, or annual basis. The more infrequent the reporting, the greater the lag in reporting and settlement loss development patterns of the reinsurer.

Ceding companies typically have relationships with multiple reinsurers; similarly, reinsurers work with multiple ceding companies as well as multiple brokers. Each of these companies and brokers will have different IT systems that generate different types of reports. Ceding companies and brokers often struggle to access data from existing systems and extract data in the formats suitable for reinsurers. Similarly, reinsurers have difficulty efficiently and accurately absorbing the data to transform into the format required for actuarial purposes. The creation, distribution, and absorption of data via bordereaux files remains a manually intensive process. Another challenge with bordereau reporting is that the loss detail on a bordereau does not contain near as complete details as are available on the claim files of the ceding company.

[41] Quoted in Larry Schiffer, "Reinsurance Terminology Explained: Bordereau and Other Terms of Art," IRMI Expert Commentary, March 2021, https://www.irmi.com/articles/expert-commentary/reinsurance-terminology-explained-bordereau.

While the insurance industry has made great strides in defining standardized data sets to be used by ceding companies and their reinsurers, the adoption of these data sets has been slow. Even when standardized formats for reporting are used, the issue of data disparity still exists. Many stakeholders have not fully implemented standardized data standards in their IT systems due to the high cost and effort required to update existing systems and the higher priority of other IT transformation initiatives.

Loss Adjustment Expenses

One area that requires the actuary's close attention is the treatment of **loss adjustment expenses** (**LAE**), which are expenses associated with the investigation, management, and settlement of claims. This text uses similar terminology to *Estimating Unpaid Claims Using Basic Techniques*. **Allocated loss adjustment expenses** (**ALAE**) correspond to those costs the insurer (or reinsurer) can assign to a particular claim, such as legal and expert witness expenses. **Unallocated loss adjustment expenses** (**ULAE**) are expenses that cannot be easily allocated to a specific claim. Examples of ULAE include the payroll, rent, and computer expenses for the claims department of an insurer (or reinsurer).

It is important that the actuary working with reinsurance (ceded and assumed) understand the treatment of LAE in reinsurance contracts. Frequently, although not always, ULAE are excluded from reinsurance coverage. For ALAE, there are generally three possible treatments:

1. Included with the claim amount in determining excess of loss coverage, which is a common treatment;
2. Included on a pro rata basis (i.e., the ratio of the excess portion of the loss to the total loss amount determines coverage for ALAE); and
3. Not included in the coverage.

For example, assume a ceding company issues liability policies with limits of 5 million and maintains liability excess per occurrence reinsurance with a retention of 2 million and limits of 3 million. Table 2. 1 presents the primary insurer's loss and ALAE on a gross of reinsurance and ceded basis for three occurrences assuming the three different options for the treatment of ALAE.

Table 2. 1. Examples of ALAE Treatment Under Reinsurance

Occurrence	Gross of Reinsurance		Ceded Loss and ALAE based on Reinsurance Treatment of ALAE		
	Loss	ALAE	ALAE Included with Loss	ALAE Included Pro Rata Basis	ALAE Not Included
#1	2	2	2	0	0
#2	3	2	3	1.67	1
#3	0	3	1	0	0

In this example, the loss and ALAE are each 2 million for occurrence #1. If ALAE are included with the loss amount covered by the reinsurance contract, then the total subject loss is 4 million, of which 2 million is retained by the ceding company and 2 million is assumed by the reinsurer. If ALAE are included on a pro rata basis for occurrence #1, there is no assumption of losses by the reinsurer, as the subject loss (i.e., 2 million) does not exceed the ceding company's retention and there are no losses to enter into a pro rata calculation. Finally, for occurrence #1, if ALAE are not included in the reinsurance contract, then there is no assumption by the reinsurer as the subject loss (i.e., 2 million) does not exceed the ceding company's retention.

For occurrence #2, the loss of 3 million exceeds the ceding company's retention even before consideration of ALAE. If ALAE are included with the loss amount covered by the reinsurance contract, then the total subject loss is 5 million, of which 2 million is retained by the ceding company and 3 million is assumed by the reinsurer. If ALAE are included on a pro rata basis for occurrence #2, there is an assumption of ALAE by the reinsurer as well as losses. The calculation for assumed ALAE (i.e., ALAE ceded to the reinsurer) is equal to:

(1 million loss assumed / 3 million total loss) x 2 million ALAE = 0.67 million ALAE assumed.

If, for occurrence #2, ALAE are not included in the reinsurance contract, then assumed losses by the reinsurer are 1 million, and the ceding company retains 2 million losses and 2 million ALAE.

Finally, for occurrence #3, the sum of the loss of 0 and ALAE of 3 million exceeds the ceding company's retention when ALAE are included. Thus, there is a recovery from the reinsurance of 1 million if ALAE are included with the loss amount covered by the reinsurance contract. Given that there are no losses that exceed the retention, there is no recovery from the reinsurer for ALAE for occurrence #3 if ALAE are covered on a pro rata basis. Finally, if for occurrence #3, ALAE are not included in the reinsurance

contract, then assumed losses by the reinsurer are nil, and the ceding company retains the full ALAE of 3 million.

Given the large amounts that can be paid for ALAE, particularly for legal and expert witness fees on liability classes of business such as medical malpractice, asbestos and environmental, and directors and officers, the treatment of ALAE and changes in such treatment over time can influence development patterns and relationships in the data and thus have implications for projections of future losses.

Multiple Currencies

Loss data for some ceding companies may exist in the IT systems in different currencies. For example, global reinsurers aggregate data across U.S. dollars, Canadian dollars, Euros, Japanese yen, Chinese Yuan, etc. Depending on the volume of losses in differing currencies, the actuary may need to adjust the data prior to the analysis. One approach is to separate the data by currency and then combine the data after translating data to a common currency using the appropriate exchange rates at a single point in time; such an approach avoids the influence of fluctuations in exchange rates over time. Another approach can be used when writing catastrophe reinsurance in a region with numerous countries and currencies (e.g., South and Central America) where losses are aggregated based on the ceding company's currency of origin.

Large Losses

It is important for the actuary to be aware of how large losses influence the different projection techniques. The presence of unusually large losses, such as those arising from a natural catastrophe event or a class action suit, can distort some of the methods used for estimating unpaid losses. In these situations, the actuary may choose to exclude the large losses from the initial projection and, at the end of the unpaid loss analysis, add a case-specific projection for the reported portion of large losses and a smoothed provision for the IBNR portion of large losses. Given the nature of reinsurance and in particular coverage on an excess of loss basis, both for individual occurrences and catastrophe events, adjusting data, methodology, and assumptions for large losses can be particularly important for the actuary working with reinsurance. When faced with unusually large losses, reinsurers frequently rely on the expertise of claims adjusters as well as input from catastrophe models to supplement traditional loss development and other basic projection methodologies.

Recoveries

Given that reinsurance is insurance for insurers, recoveries (such as deductibles, salvage, and subrogation) that are applicable to the subject loss generally apply before the cession for both proportional and excess of loss reinsurance. It is important for the actuary working with reinsurance to understand the processes related to the recording of payment and case outstanding for recoverables. Some primary insurers establish a case outstanding net of the deductible, while others do not consider the deductible in the establishment of the case outstanding. Even within the same insurer, practices may vary between lines of business. Similar differences in procedures can exist with respect to the establishment of case outstanding for salvage and subrogation recoveries.

Actuaries working with primary insurers and reinsurers should take care to understand how recoveries are applied, particularly for large property losses that can take time to settle all aspects of the claim, especially business interruption losses than can extend over multiple years. For example, assume the following:

- For calendar year 2019, a primary insurer wrote 10 million limit commercial property policies and maintained commercial property excess per risk reinsurance with a retention of 2 million and limits of 8 million.
- An insured incurred a major fire due to an explosion of the boiler on January 2, 2019, which resulted in property losses as well as substantial business interruption losses for a total loss of 7 million gross of salvage and subrogation recoveries.[42]
- The primary insurer paid losses of 2 million in 2019, 3 million in 2020, and the final 2 million in 2021.
- During 2019, expected salvage recoveries of 0.25 million were received.
- During 2022, the ceding company received an unexpected subrogation recovery from the boiler manufacturer of 1.5 million. At year-end 2019, carried reserves reflected the losses net of salvage but without the subrogation that was received in 2022.

For year-end 2019, the ceding company would report losses net of reinsurance and salvage of 2 million and ceded losses of 4.75 million to the reinsurer (total gross loss of 7 million minus salvage of 0.25 million minus the retention of 2 million). In 2022, the primary company receives the subrogation payment of 1.5 million and would transfer this entirely to the reinsurer. Thus, there is no benefit to the ceding company (or change in financial results on a net of reinsurance basis) of the unexpected subrogation, and the benefit is solely for the reinsurer.

If the total losses net of salvage were only 2.75 million instead of 6.75 million, then a subrogation recovery of 1.5 million would reduce the total value of the claim below the reinsurance retention. Any payments by the reinsurer would be returned, and then the remaining subrogation recovery would accrue to the benefit of the ceding company. In this revised example, the ceding company would report losses net of reinsurance and salvage of 2 million for year-end 2019 and cede losses of 0.75 million to the reinsurer. In 2022, the reinsurer would receive reimbursement of 0.75 million from the unexpected subrogation, and the ceding company would also report favorable development of 0.75 million, the balance of the 1.5 million subrogation recovery.

Challenges with Data for Reinsurer

Influence of Change in Operations and the Environment

The actuary working for a reinsurer can face greater challenges than the actuary working for a primary insurer in understanding the effects of operational changes on the estimation of unpaid losses. This is in part because operational changes can take place at the reinsurer as well as at the ceding companies,

[42] For purpose of this example, assume the loss values are accurate and there is no further development on the claim.

and both can influence the projection of ultimate losses and resulting estimates of unpaid losses. Over the past 20 years, many insurers have instituted significant transformational projects to modernize systems including the implementation of new policy administration and claims administration systems. Many insurers have increased the use of analytics and big data to influence pricing, marketing, and underwriting. These transformational initiatives can affect the operations of the ceding companies, their target markets, how risks are underwritten and how claims are reported and settled, as well as the types of data available. All of these changes can influence the reporting and payment patterns of ceded losses. Similarly, reinsurers have undertaken major transformational initiatives that influence loss reporting and settlement practices.

Further changes arise when ceding companies acquire and divest business (companies and large portfolios), and the actuary needs to understand how such activities affect losses historically and in the future. Finally, actuaries need to understand the legal and economic environments of the ceding companies. For example, major reforms in a large jurisdiction (such as tort reform or product reform in coverages such as automobile or workers' compensation insurance) can have major implications on the loss experience of ceding companies that is passed on to reinsurers.

Other Experience Typically Excluded from Development Analyses

Changes in the operations and environment may lead the actuary to choose to exclude discontinued business (i.e., business in run-off) from the analysis because such data could distort historical patterns and relationships, particularly for more recent years. Discontinued business may not be representative of the portfolio of ongoing business, and thus development patterns and loss ratios, which are key assumptions of basic actuarial techniques, should be selected that reflect the characteristics of the ongoing business. This is true when selecting assumptions for reporting and settlement of losses as well as with frequency and severity of losses (albeit reinsurers often do not have sufficient data to project frequencies and severities). Furthermore, some types of discontinued business (such as asbestos, environmental impairment liability, and abuse) may not be suited to development triangle analyses.

Reporting Lags

As described in Chapter 1, reinsurance is insurance for insurers. Thus, claims must first be reported and investigated by the ceding company before loss data can be reported to the reinsurer. As a result, loss data for reinsurers lag those of the ceding companies, and, at times, the lag can be significant. Delayed reporting is particularly true for excess of loss reinsurance, where there is not only a lag because of the need to report to the primary insurer first but also because these claims often take time for the insurer to realize that the claim may exceed its retention, especially for liability claims.

Reinsurers recognize the challenges associated with lags in reporting and often incorporate reporting requirements in the reinsurance contract. For example, the ceding company may be required to report a claim once it reaches a certain threshold, which may be expressed as a dollar value or a percentage of the ceding company's retention (i.e., the reinsurer's attachment point). Alternatively, a ceding company may be required to report certain types of claims that are known to have a higher likelihood of resulting in large losses (such as an abuse claim or a class action suit) regardless of amount.

Heterogeneity of Contract Wordings

The manuscript nature of reinsurance contracts is mentioned repeatedly in this chapter. Patrik states that the "heterogeneity of contract wordings also means that whenever you are accumulating, analyzing, and comparing various reinsurance data, you must be careful that the reinsurance coverages producing the data are reasonably similar."[43] This concern is true when using internal and external data.

Sources of Data

With respect to sources of data for actuarial work, *ISAP 1* states:

> To the extent possible and appropriate when setting assumptions, the actuary should consider using data specific to the organization or the subject of the actuarial services. Where such data are not available, relevant, or sufficiently credible, the actuary should consider industry data, data from other comparable sources, population data, or other published data, adjusted as appropriate. The data used, and the adjustments made, should be described in any report.[44]

Actuaries working for large reinsurers are typically able to rely on detailed loss and premium data from their own IT systems. Internal data may be based on the experience of an individual reinsurer or aggregated experience from affiliated reinsurers within a group.

Smaller reinsurers, however, can face more challenges with data due to IT limitations as well as limitations in the volume and homogeneity of losses. Thus, actuaries working with small reinsurers often need to seek external data sources. External data can be valuable when analyzing development factors (particularly tail factors), trend rates, and expected loss ratios, as well as when the actuary evaluates and attempts to reconcile the results of various projection methods.

There are not nearly as many external data sources for reinsurance as there are for primary insurance. For reinsurance, actuaries can turn to the following:

- Reinsurance Association of America (RAA)
- *Best's Aggregates & Averages*
- Reports from global brokers, such as Guy Carpenter, Aon, and Willis Towers Watson
- Reports from global reinsurers, such as Swiss Re, Munich Re, and SCOR S.E.
- Other internet searches

[43] Patrick, "Reinsurance," 344.

[44] *ISAP 1*, section 2.5.3.

Reinsurance Association of America (RAA)

The RAA is the leading trade association of P&C reinsurers doing business in the United States. Members of the RAA include reinsurance underwriters and intermediaries licensed in the United States and those that conduct business on a cross-border basis. Since 1969, the RAA has published a biannual study of loss development triangles. The RAA study includes historical loss development patterns by accident year for reinsurers writing casualty excess reinsurance for automobile liability, general liability, and medical malpractice. In addition, the RAA study does the following:

- Organizes patterns separately by treaty and facultative business and five ranges of attachment points.
- Presents data of broad historical loss development composites by a cross-section of reinsurers.
- Discusses how loss development patterns have changed over the last few years and suggests possible reasons for those changes.
- Discusses how loss development has varied depending on the circumstances and the nature of the business being considered.[45]

Best's Aggregates & Averages

The data available in *Best's Aggregates & Averages*[46] exemplify the differences in segmentation of insurance and reinsurance data. Schedule P, which contains data for U.S. insurers, separately presents the loss and premium data for major lines of business including three non-proportional reinsurance segments:

- Reinsurance – non-proportional assumed property;
- Reinsurance – non-proportional assumed liability; and
- Reinsurance – non-proportional assumed financial lines.

Schedule P–Part 1 contains 10 years of data sorted by the year in which premiums were earned and losses incurred. The types of data include earned premiums, loss and expense payments and reserves, and salvage and subrogation received and anticipated. Unlike primary insurance, Schedule P–Part 1 for the three reinsurance segments does not include data for the number of reported claims and the number of claims outstanding.

Schedule P–Part 2 contains incurred (which includes sum of paid, case outstanding, and IBNR) net losses and defense and cost containment expenses, and Schedule P–Part 3 contains cumulative paid losses and defense and cost containment expenses. Bulk and IBNR reserves on net losses and defense and cost

[45] "Historical Loss Development Study," RAA, https://www.reinsurance.org/ProductDetail.aspx?id=147.

[46] *Best's Aggregates & Averages* is an annual publication that benchmarks the performance of individual insurance companies and insurance groups against industry totals, segments, and composites. The publication includes balance sheet, summary of operations, and annual statement. For further information, see http://www.ambest.com/sales/AggAvg/default.asp.

containment expenses are included in Schedule P–Part 4. The reinsurance triangles include data for 10 accident years and evaluations from 12 to 120 months.

While actuaries working with reinsurers may find some value in the aggregated industry data contained in Schedule P, there are important limitations including but not limited to:

- An experience period of only 10 years, which is typically not long enough for excess of loss reinsurance.
- Segmentation that is not sufficiently refined by major line of business and type of reinsurance.
- The combination of experience that may not reflect targets markets, terms and conditions, and operations of any individual reinsurer.

Reinsurance data that are aggregated by accident year for Schedule P tend to look and behave more like primary insurance data, which is generally not an accurate portrayal of the volatility and long-tail nature of many reinsurance losses. Reinsurance actuaries who rely on data aggregated by treaty year will view data much differently than the lines of business included in Schedule P of the U.S. annual statement.

Internet Searches

Another potential source for external data can be found through online searches of publicly available reinsurer data. Generally, these triangles are presented on a worldwide basis and are highly aggregated by major line of business.

It is important to note that many of the reinsurers who publish triangles based on worldwide consolidated experience state that, in practice, their actuaries review between 50 to 500 separate segments for reserving purposes. One global reinsurer describes the governance process around segmentation and the objective to form segments that are "based on a variety of criteria (proportional basis or not, underlying risks typology, geography, pricing environments, legislative environments)."[47] It is important to recognize that data aggregated across many countries, lines of business, and types of reinsurance would likely not be deemed sufficient without some modification (that should be documented in accordance with professionalism requirements) for actuarial work related to a single reinsurer in a particular jurisdiction.

Shortcomings of External Data

Actuaries need to be aware of the potential shortcomings in the use of external data. While similar considerations apply to actuaries working with primary insurance, the issues are heightened for actuaries working with reinsurance. There is a risk that external data may be misleading or irrelevant due to differences in the following:

[47] *SCOR's Loss Development Triangles and Reserves* (SCOR, December 2010), 9, https://www.scor.com/sites/default/files/2011_trianglesdisclosure.pdf.

- Manuscript wording and terms and conditions, where contracts can vary significantly.
- Mix of assumed business, particularly differences by major industry, region, attachment points, and policy limits.
- Types of reinsurance (e.g., treaty, facultative, proportional, and non-proportional).
- Underwriting processes, including engineering and risk control services.
- Claims management philosophies and processes.
- Coding and IT systems.

Thus, the actuary must carefully evaluate the relevance and value of external data.

Conclusion – Importance of Understanding the Data

In conclusion, it is critically important for actuaries to fully appreciate their obligations with respect to data. Actuaries should understand the different types of data that are inputs to and outputs from the insurer's and reinsurer's information systems. Ceding companies and brokers who report on behalf of ceding companies may use the same term to mean different things. The actuary is responsible for knowing the true meaning of the types of loss data contained in the loss reports and information systems that are used as inputs for the estimation of unpaid losses. The importance of understanding the data is equally applicable to actuaries working with primary insurance and reinsurance.

Chapter 3 – Methods Frequently Used to Estimate Unpaid Losses for Reinsurance

This chapter addresses three of the most frequently used methods for estimating unpaid losses: development, expected, and Bornhuetter-Ferguson methods. The chapter is organized in the following major sections:

- Introductory Comments
- Review of the Development, Expected, and Bornhuetter-Ferguson Methods
- Background About Examples
- Comparison of Age-to-Age Factors and Development Patterns
- Implications of the Volatility in Loss Development Experience
- Quota Share and Stop-Loss Reinsurance Examples

As noted in Chapter 1, it is assumed that readers of this text are knowledgeable about basic reserving including typical data requirements, key assumptions, and the traditional methodologies (such as the development, expected loss, and Bornhuetter-Ferguson techniques). Thus, the focus of this chapter is on differences in reserving for reinsurance versus primary insurance and not on detailed mechanics of the traditional projection techniques.[48]

Introductory Comments

For financial reporting, planning, and risk management purposes, actuaries estimate unpaid losses on a gross, ceded, and net of reinsurance basis. For primary insurers, ceded losses reflect business transferred to reinsurers. For reinsurers, gross losses represent the business they assume, and ceded losses reflect the business that they retrocede. The two basic approaches for determining these three estimates of unpaid losses include the following:

- Projecting ultimate losses and the resulting unpaid losses (i.e., ultimate losses minus paid losses) on a gross of reinsurance basis and net of reinsurance basis, then estimating ceded unpaid losses as the difference; and
- Projecting ultimate losses and the resulting unpaid losses on a gross of reinsurance basis and ceded basis, then estimating net unpaid losses as the difference.

Ceded data often have limited credibility due to a lower volume of losses, higher volatility associated with large claims and catastrophe events, and frequent changes in terms and conditions (such as attachment points, limits, participation percentages, and treatment of ALAE) that result in data that are

[48] For further information, see Friedland, Estimating Unpaid Claims Using Basic Techniques.

not homogeneous. Thus, actuaries typically use the first approach and select development patterns and expected loss ratios, which are key assumptions of the projection methods, gross and net of reinsurance rather than gross and ceded.

To project ultimate values and estimate unpaid losses, actuaries frequently use the development, expected, and Bornhuetter-Ferguson methods.

Review of the Development, Expected, and Bornhuetter-Ferguson Methods

The following descriptions of key assumptions and the major steps of the three projection methods are based on those in *Estimating Unpaid Claims Using Basic Techniques*.

Development Method

Key Assumptions

The distinguishing characteristic of the development method is that ultimate values for each year[49] in the experience period are produced from recorded values assuming that future development is similar to prior years' development. For reinsurers, the development method is used most frequently with reported and paid losses as well as with premiums. The underlying assumption in the development method is that values recorded to date will continue to develop in a similar manner in the future (i.e., the past is indicative of the future).

An implicit assumption in the development technique is that, for an immature year, the losses (or premiums) observed thus far tell the actuary something about the losses (or premiums) yet to be observed. This contrasts with the primary assumption underlying the expected method and the Bornhuetter-Ferguson method, where the unrecorded (unreported or unpaid) losses are based on an *a priori* (or initial) estimate of losses.

Other important assumptions of the development method include consistency throughout the experience period in claim processing, the mix of business (and resulting losses), policy limits, and reinsurance coverage (e.g., retention, participation percentage, and policy limits).

Mechanics

The development method consists of seven basic steps:

1. Compile development data in a development triangle.
2. Calculate age-to-age factors.

[49] For insurers, the "years" are typically accident years. For reinsurers, the years are often treaty (or underwriting) years, although accident years are used by reinsurance actuaries in the United States and Canada due to regulatory financial reporting requirements.

3. Calculate average age-to-age factors.
4. Select development factors for each age-to-age interval.
5. Select tail factor.
6. Calculate cumulative development factors.
7. Project ultimate values.

One of the major differences in projecting ultimate losses for primary insurance and reinsurance is the credibility of the reinsurance data that, as noted previously, tends to be lower for reinsurance due to volume, volatility, and heterogeneity of the data. By their nature, losses associated with excess of loss reinsurance can be substantially more volatile than ground-up losses. This is true for catastrophe coverage as well as reinsurance at high attachment points, where significant frequency of claims is not expected.

Considerations in Selecting Age-to-Age Factors

In *Estimating Unpaid Claims Using Basic Techniques*, there is an important discussion about the characteristics the actuary looks for in the selection of age-to-age factors:

- *Smooth progression of individual age-to-age factors and average factors across development periods.* Ideally, the pattern should demonstrate steadily decreasing incremental development from valuation to valuation, especially in the later valuations. Such decreases are seen in many, although not all, of the examples presented later in this chapter.
- *Stability of age-to-age factors for the same development period.* Ideally, there should be a relatively small range of factors (small variance) within each development interval (i.e., down the columns). The actuary looks for stability within the age-to-age factors themselves as well as within the various averages for the same development period. For both reported and paid losses, the greatest variability in age-to-age factors is typically seen at early age-to-age intervals, where losses are at their most immature state (i.e., when the claims professionals have the least amount of information about the circumstances of the insured event and the potential damages and injuries of claimants). There tends to be much greater volatility in the age-to-age factors for reinsurance when compared with primary insurance and for non-proportional reinsurance when compared with proportional reinsurance, and such differences are seen repeatedly in the examples included in this chapter.
- *Credibility of the experience.* Actuaries generally determine credibility based on the volume and the homogeneity of the experience for a given year and maturity age. If the loss development experience has low credibility because of the limited volume of losses, organizational changes, or other factors, it may be necessary to use benchmark development factors. (See the discussion in Chapter 2 about the use of external data.)
- *Changes in patterns and applicability of the historical experience.* Actuaries determine the appropriateness of historical age-to-age factors for projecting future development based on quantitative and qualitative information regarding changes in the book of business and operations over time. There are numerous reasons why historical development experience may not be appropriate, such as

- Dramatic changes in volume of premiums and claims.
- Presence of large claims that distort the development experience.
- Significant changes in the portfolio that are not captured by trend rates.
- Changes in claims processing that affect the manner in which claims are reserved and paid.

Actuaries also consider the effect of changes in external factors that have not yet manifested themselves in the recorded experience (i.e., reported losses, paid losses, or premiums).

All of these considerations are equally applicable to actuaries working with primary insurance and reinsurance.

Expected Method

The expected method is frequently used when:

- Entering a new line of business or new region.
- Changes in strategy, operations, or the environment that make recent historical loss data irrelevant for projecting future loss activity for a particular cohort of losses.
- The development method is not appropriate for less mature periods because the development factors to ultimate are too highly leveraged.
- Data are unavailable for other methods.

Each of these situations is equally applicable to actuaries working with primary insurance and reinsurance.

Key Assumptions

The key assumption of the expected method is that the actuary can better estimate total unpaid losses based on an a priori estimate than from loss experience observed to date. In certain circumstances, the losses reported to date may provide little information about ultimate losses, especially when compared with the a priori estimate.

Mechanics

The most common approach for estimating expected losses associated with reinsurance is an expected loss ratio multiplied by earned premium. The expected loss ratio is often based on pricing information, industry data, and historical experience adjusted to the conditions of the year under review. In selecting the expected loss ratio, the actuary seeks input from management and considers changes in market conditions, pricing, terms and conditions, underwriting, claims emergence, and other factors that could influence expected ultimate losses.

In addition to the expected loss ratio, actuaries working with primary insurance also use frequency-severity and exposure-loss cost approaches to estimate expected losses. In contrast, actuaries working with reinsurers typically do not have access to detailed claim count and exposure information. For a reinsured, estimating ceded losses can be complicated by reinsurance coverage that spans across multiple lines of business or years, which can complicate the assignment of claim counts and exposure units with losses. Actuaries can also use complex stochastic models to estimate expected losses; such models are outside the scope of this text.

Bornhuetter-Ferguson Method

Actuaries rely on the Bornhuetter-Ferguson method almost as often as they rely on the development method. The Bornhuetter-Ferguson method is essentially a blend of the development and expected methods. In the development method, the actuary multiplies actual losses by a cumulative development factor. This method can lead to erratic, unreliable projections when the cumulative development factor is large because a relatively small swing in reported losses or the reporting of an unusually large loss could result in a very large swing in projected ultimate losses. In the expected method, the unpaid loss estimate is equal to the difference between a predetermined estimate of expected losses and the actual payments. This has the advantage of stability but completely ignores actual results as reported. The Bornhuetter-Ferguson method combines the two methods by splitting ultimate losses into two components: actual reported (or paid) losses and expected unreported (or unpaid) losses. As experience matures, more weight is given to the actual losses and the expected losses become gradually less important.

Key Assumptions

The key assumption of the Bornhuetter-Ferguson method is that unreported (or unpaid) losses will develop based on expected losses. In other words, the losses reported to date contain no information about the amount of losses yet to be reported. This is different from the development method where the primary assumption is that unreported (or unpaid) losses will develop based on reported (or paid) losses to date.

Mechanics

As noted, the Bornhuetter-Ferguson method is a blend of the development and expected methods. The following two formulae represent the reported and paid Bornhuetter-Ferguson methods, respectively:

$$\begin{aligned}\text{Ultimate Losses} &= \text{Actual Reported Losses} + \text{Expected Unreported Losses} \\ &= \text{Actual Reported Losses} + (\text{Expected Losses}) \times (\%\ \text{Unreported}) \\ \text{Ultimate Losses} &= \text{Actual Paid Losses} + \text{Expected Unpaid Losses} \\ &= \text{Actual Paid Losses} + (\text{Expected Losses}) \times (\%\ \text{Unpaid})\end{aligned}$$

Given that the actual reported and paid losses are both known quantities, the challenge of the Bornhuetter-Ferguson method is to calculate the expected unreported and expected unpaid losses. To complete the Bornhuetter-Ferguson method, the actuary must select loss development patterns and

develop an expected loss estimate. The development factors are typically based on the selection of age-to-age factors from the development method applied to the insurer's historical data, but they can also be based on external data.

Further Comments about the Development, Expected, and Bornhuetter-Ferguson Methods

Detailed Calculations

Detailed step-by-step explanations and calculations for the development, expected, and Bornhuetter-Ferguson methods are included in *Estimating Unpaid Claims Using Basic Techniques* and are not repeated in this text. The three methods can be used with reported losses, paid losses, and claim counts, although claim counts are used far less with reinsurance than with primary insurance. In carrying out each of these methods, issues related to the types of data required, considerations regarding the selection of assumptions, and the mathematical steps to project ultimate values are similar for primary insurance and reinsurance.

Differences in Assumptions for Reinsurance and Primary Insurance

While the mechanics for each of the methods are the same for actuaries working with primary insurance and reinsurance, there are important differences in assumptions. For example, for reinsurance:

- For a similar line of business, loss development factors in the earlier maturity age intervals are often higher for reinsurance than for primary insurance due to reporting lags. (See Chapter 2 for further discussion about the drivers of reporting lags in reinsurance). Tail factors can also be higher, particularly for non-proportional reinsurance when compared with primary insurance and for non-proportional when compared with proportional reinsurance for a similar line of business.
- Loss trend factors tend to be higher for excess of loss reinsurance than primary insurance.
- There is often less precision in premium on-level factors that adjust for rate changes. Actuaries working with primary insurance regularly maintain detailed information about historical rate changes by major jurisdiction and line of business, especially where rates are highly regulated. These actuaries use premium on-level factors to adjust historical premiums to current rate levels. The rate change information available for reinsurers can be far more challenging to quantify given the manuscript nature of reinsurance arrangements and the changes in coverage that can occur from year to year. Nevertheless, reflecting rate changes is important when determining expected loss ratios for the expected and Bornhuetter-Ferguson methods for reinsurance.[50]
- In reinsurance, there is more limited use of adjustment factors for changes such as tort and product reform than that seen with primary insurance.

[50] For examples of the calculation of premium on-level factors, see chapter 5 of Geoff Werner and Claudine Modlin, *Basic Ratemaking* (CAS, 2016), 64–89, https://www.casact.org/library/studynotes/Werner_Modlin_Ratemaking.pdf.

The use of professional judgment is particularly important for actuaries working in reinsurance. In selecting assumptions, actuaries should consider professionalism requirements as set forth in applicable actuarial standards of practice, which should be reviewed on a regular basis.

Effect of Changes in Currency Exchange Rates

Changes in currency exchange rates often influence how an actuary working with reinsurance aggregates losses in development triangles. Many global reinsurers who aggregate experience on a global basis review triangles at the prevailing exchange rates to prevent distortions in the age-to-age factors arising from fluctuations in currency exchange. This leads to differences in the values within the triangles from analysis to analysis.

An example helps demonstrate the effect of changes in currency exchange on age-to-age factors. Two reported loss development triangles are constructed based on the following assumptions:

- Cumulative reporting loss pattern of 20%, 60%, 90%, and 100% at 12, 24, 36, and 48 months, respectively.
- Ultimate losses of 1 million Euros for accident year 2014 with 20% each for the United States, Canada, Japan, U.K., and the rest of Europe.
- Annual growth in losses for each country of 5%.

The exchange rates at December 31 of each year are used to create the two triangles. In the first triangle, presented in Table 3. 1, reported loss are based on each country's reported losses restated at each maturity age at the currency exchange rate of December 31, 2019.

Table 3. 1. Global Reported Losses Based on Currency Exchange Rates at December 31, 2019

Accident Year	12	24	36	48	60	72
2014	206	618	927	1,030	1,030	1,030
2015	216	649	973	1,082	1,082	
2016	227	681	1,022	1,136		
2017	238	715	1,073			
2018	250	751				
2019	263					

In the second triangle, reported losses are based on the aggregation of reported losses from each country using the exchange rate at December 31 of each year. For example, the reported losses of the United States are adjusted by the triangle of US$-Euro exchange rates seen in Table 3. 2.

Table 3. 2. US$-Euro Exchange Rates

Accident Year	12	24	36	48	60	72
2014	1.21100	1.08660	1.05225	1.19990	1.14550	1.12270
2015	1.08660	1.05225	1.19990	1.14550	1.12270	
2016	1.05225	1.19990	1.14550	1.12270		
2017	1.19990	1.14550	1.12270			
2018	1.14550	1.12270				
2019	1.12270					

Reported losses for each of the other countries are similarly adjusted to produce the global reported loss triangle seen in Table 3. 3.

Table 3. 3. Global Reported Losses Based on Currency Exchange Rates at Each Year-End

Accident Year	12	24	36	48	60	72
2014	200	626	942	977	995	1,030
2015	219	659	924	1,045	1,082	
2016	231	647	987	1,136		
2017	226	691	1,073			
2018	242	751				
2019	263					

Not surprisingly, the age-to-age factors are noticeably different dependent on how losses are adjusted for currency exchange. Table 3. 4 compares the age-to-age factors of the first reported loss triangle with those of the second reported loss triangle.

Table 3. 4. Age-to-Age Factors for Global Reported Losses

Accident Year	12-24	24-36	36-48	48-60	60-72
	Reported Losses Adjusted by Dec 31, 2019 Exchange Rates				
2014	3.00	1.50	1.11	1.00	1.00
2015	3.00	1.50	1.11	1.00	
2016	3.00	1.50	1.11		
2017	3.00	1.50			
2018	3.00				
	Reported Losses by Exchange Rates at Each Year-end				
2014	3.13	1.51	1.04	1.02	1.04
2015	3.01	1.40	1.13	1.04	
2016	2.80	1.53	1.15		
2017	3.05	1.55			
2018	3.11				

Adjusting losses by a common currency exchange rate allows for the true reporting pattern to be seen without distortions from currency exchange. While the example is simplistic, in practice, the process can be complicated. Thus, adjustments to assumed losses for the effect of changes in currency can be extremely difficult and require approximations by the actuary.

Background About Examples

The examples included in this chapter are based primarily on the worldwide aggregated data of the largest reinsurers obtained from internet searches. The data are disguised through additive and multiplicative adjustments applied to reported and paid losses as well as earned premiums. The actual years in the experience period are not identified, in part so that the examples do not become dated with the passage of time. Similarly, the currency and units (i.e., thousands or millions) are not identified. It is not the purpose of this text to evaluate any specific reinsurer's experience but instead to explore common relationships between primary insurance and reinsurance and between different types of reinsurance.

Given that the examples in this chapter are constructed from the aggregated global experience of the world's largest reinsurers, the experience in these examples tends to have far greater stability than what an actuary actually sees when analyzing reinsurance experience by HRG. For financial reporting, reinsurers aggregate their experience into roughly 10 to 20 segments. In the commentary supporting the publicly available financial reports, one reinsurer notes that a single segment in their financial report includes the experience of 40 HRGs. One reinsurer reported that they maintain more than 500 HRGs, and another uses more than 1,000 HRGs for actuarial reserving analyses. Thus, the loss development triangle for a particular HRG for a reinsurer would be expected to have significantly less data with

substantially more volatility than the examples of this chapter. It is not unusual for the loss development triangles for some HRGs to have values of nil.

Numeric examples are presented to examine the relationships in development experience for the following:

- Primary insurance and reinsurance for a similar type of business (professional lines, Exhibit I).
- Proportional and non-proportional reinsurance for the same line of business (liability, Exhibit II).
- Reinsurance excluding catastrophe and reinsurance catastrophe (property, Exhibit III).

For each of these examples, detailed exhibits are included at the end of the chapter and organized as follows:

- Sheets 1–4: Reported and paid loss development triangles including data and age-to-age factors, and cumulative development factors.
- Sheet 5: Reporting and payment patterns.
- Sheet 6: Development of expected loss ratios.
- Sheet 7: Projection of ultimate losses using expected method and Bornhuetter-Ferguson method.
- Sheet 8: Estimation of IBNR and total unpaid losses.

Data for the professional lines example are aggregated by accident year, and the data for the liability and property examples are aggregated by treaty year. For these latter two examples, the treaty year premium must be adjusted to reflect earnings at the end of the year when estimating unpaid losses, and details of these calculations are presented later in this chapter and in Sheet 8 of Exhibits II and III. An example of the development of written premium to ultimate is included for liability non-proportional and facultative reinsurance in Exhibit II, Sheet 9.

The development examples in this chapter incorporate several simplifying approaches that are described below.

Average Age-to-Age Factors

Three average age-to-age factors are calculated: simple three years, medial seven years (i.e., average of seven years excluding high and low values), and volume weighted five years. The intent is to present averages from different time periods to demonstrate potential volatility in these averages. In practice, the actuary would select the types of average and the experience periods for averages that reflect the specific circumstances of the insurer or reinsurer, its internal and external environments, and the credibility of the data.

Tail Factors

Tail factors for reported losses are selected based on the maximum of 1.00 and the latest observed factor (e.g., the reported tail factor from 120 months-to-ultimate is based on the maximum of 1.00 and the observed factor from 108-to-120 months). Tail factors for paid losses are derived from a review of the projected ultimate losses using the development method with reported losses for the most mature years. In practice, the actuary would use several approaches to select the tail factor. One approach is to rely on industry benchmark development factors. Another common approach is to fit a curve to the selected or observed development factors to extrapolate the tail factors. Many commercial reserving software programs as well as open-source code have routines for such extrapolation. A more in-depth discussion of tail factors is beyond the scope of this text. Actuaries seeking additional information are referred to actuarial literature available on the CAS web site and the CAS Tail Factors Working Party.

Expected Loss Ratios

The projected ultimate losses using the development method applied to paid and reported losses are shown on the exhibit for the development of expected loss ratios. For these examples, the initial estimates of ultimate losses are based solely on the projections using reported losses. In practice, the actuary would likely consider reported loss and paid loss development projections as well as expected loss ratios from pricing or financial planning and possibly also industry information.

In deriving expected loss ratios, there are no adjustments for loss or premium trend, changes in rate level, the effect of tort reform, or other changes in the claims environment, all of which could be significant. Four averages are calculated (latest three, five, and seven years and latest five years excluding high and low), and the selected expected loss ratio is based on the latest five years. The selected expected loss ratios are then used for the expected and Bornhuetter-Ferguson projections.

For the examples that rely on data aggregated by treaty year, an adjustment is required for premium to reflect earnings through the valuation date.

GL Captive Insurer

Data for the two final examples of this chapter use GL Captive Insurer, which is based on GL Self-Insurer from *Estimating Unpaid Claims Using Basic Techniques*. These examples present the perspective of a ceding company as opposed to the reinsurer.

Comparison of Age-to-Age Factors and Development Patterns

As noted previously, examples are presented to examine the relationships in development experience for the following:

- Primary insurance and reinsurance for a similar type of business.
- Proportional and non-proportional reinsurance for the same line of business.

- Property reinsurance excluding catastrophe and property reinsurance catastrophe.

Primary Insurance and Reinsurance for a Similar Type of Business

The first example, presented in Exhibit I at the end of this chapter, relies on the development data for professional lines of a global insurer that writes primary insurance and reinsurance. The focus is on the volatility of age-to-age factors and the differences in reporting and payment patterns. Greater volatility in age-to-age factors can lead to greater volatility in the indications of expected loss ratios for reinsurance when compared with primary insurance.

For professional lines of business, claim payment and reporting patterns are considered to be medium to long tail in nature for both primary insurance and reinsurance. For the primary insurance, the professional lines HRG includes the following:

- Directors & Officers (D&O) Liability.
- Employment Practices Liability (EPL).
- Fiduciary Liability.
- Crime.
- Errors & Omissions (E&O).
- Cyber Liability.
- Professional Indemnity.
- Other financial insurance related coverages for public and private commercial enterprises, financial institutions, non-profit organizations, and professional service providers.

Professional lines primary business is written predominantly on a claims-made basis.

For the reinsurance, the professional lines HRG includes:

- D&O liability
- EPL
- Medical malpractice
- Professional indemnity
- Environmental liability
- Miscellaneous E&O

D&O liability is a much greater proportion of the reinsurance business than the primary insurance business. For this example, the professional lines liability reinsurance HRG includes both non-proportional and proportional treaties, although the majority of exposures are excess policies. D&O exposures typically attach at higher levels than the rest of the portfolio. Like the primary insurance, the reinsurance is predominantly written on a claims-made basis, and most treaties are written on a risks-attaching basis.

Exhibit I, Sheets 1–4 present reported and paid loss development triangles, age-to-age and average age-to-age factors, and cumulative development factors. Reporting and payment patterns are summarized in Exhibit I, Sheet 5.

Comparison of Volatility in Age-to-Age Factors

The standard deviation and absolute differences of the age-to-age factors are calculated for each age-to-age interval from 12–24 months through 72–84 months as measures of the volatility in the reported and paid loss development. The standard deviation is a measure of the amount of variability (i.e., dispersion) in the age-to-age factors around the average. The absolute difference is equal to the highest age-to-age factor minus the lowest age-to-age factor. Table 3. 5 summarizes these results.

Table 3. 5. Professional Lines
Measures of Variability in the Age-to-Age Factors

	Age-to-Age Interval					
	12-24	24-36	36-48	48-60	60-72	72-84
	Standard Deviation - Reported Age-to-Age Factors					
Insurance	0.50	0.06	0.05	0.07	0.04	0.03
Reinsurance	0.84	0.16	0.14	0.10	0.08	0.12
	Standard Deviation - Paid Age-to-Age Factors					
Insurance	0.73	0.17	0.18	0.10	0.07	0.03
Reinsurance	2.91	0.46	0.19	0.12	0.07	0.04
	Absolute Difference - Reported Age-to-Age Factors					
Insurance	1.763	0.177	0.163	0.189	0.093	0.081
Reinsurance	2.181	0.528	0.379	0.257	0.214	0.263
	Absolute Difference - Paid Age-to-Age Factors					
Insurance	2.167	0.516	0.539	0.274	0.180	0.062
Reinsurance	7.643	1.179	0.568	0.331	0.179	0.080

As expected, there is more volatility seen at the earlier maturity ages with paid losses than with reported losses for both primary insurance and reinsurance due to the longer time frame for claims settlement and thus lower volume of paid loss data. One also readily observes much greater volatility in the age-to-age factors for the professional lines reinsurance when compared with the professional lines primary insurance. In this example, the differences are evident in both the reported loss and paid loss age-to-age factors and extend from 12–24 months through 72–84 months. Greater volatility in age-to-age factors can lead to greater uncertainty in the selection of age-to-age factors and resulting projections of ultimate losses.

Longer Reported and Payment Patterns for Reinsurance versus Primary Insurance

In Exhibit I, Sheet 5, reporting and payment patterns based on the three averages (i.e., simple three, medial seven, and volume weighted five) are shown for professional lines primary insurance and reinsurance. One readily observes longer (i.e., slower) reporting and payment patterns for the reinsurance than the primary insurance. The reasons for longer patterns are related to the lags in reporting that were previously discussed in Chapter 2 and include the need for the claims to first be recognized by the ceding company before they can be reported to the reinsurer, the time required for claims to develop beyond the ceding company's attachment point, and delays associated with bordereau reporting.

It is important to remember that these examples use a very simplistic approach for the selection of tail factors. In practice, the actuary would conduct a much more comprehensive analysis of the potential for losses beyond the experience period, and tail factors for reported and paid losses could be significantly different from the selections in this chapter's examples.

Proportional and Non-proportional Reinsurance for the Same Line of Business

While the previous example compared the volatility in losses for a similar type of business for primary insurance and reinsurance, this next example compares the loss experience for the same line of business. The development triangles included in this section are based on the experience of a global reinsurer for liability proportional treaty reinsurance and liability non-proportional treaty and facultative reinsurance. The focus of this example is on the volatility of age-to-age factors and the ratios of paid-to-reported losses as well as the length of the development patterns. Exhibit II, Sheets 1–4 present the reported and paid loss triangles. Exhibit II, Sheet 5 contains the reporting and payment patterns for liability proportional treaty reinsurance and liability non-proportional treaty and facultative reinsurance.

There are two notable differences in the loss development patterns of this example:

- There is significantly more volatility in the age-to-age factors for the non-proportional treaty and facultative reinsurance than for the proportional treaty reinsurance.
- The cumulative development factors are greater (i.e., longer development patterns) for the non-proportional treaty and facultative reinsurance than for the proportional treaty reinsurance.

Further details about these two observations follow.

Comparison of Volatility in the Age-to-Age Factors of Proportional versus Non-proportional Reinsurance

Table 3. 6 summarizes the standard deviations and absolute differences of the age-to-age factors from 12–24 months through 72–84 months. The greater volatility of the reported and paid losses is readily apparent when comparing the experience of proportional treaty and non-proportional treaty and facultative experience for the liability line of business.

Table 3. 6. Liability Reinsurance
Measures of Variability in the Age-to-Age Factors

	Age-to-Age Interval					
	12-24	24-36	36-48	48-60	60-72	72-84
	Standard Deviation - Reported Age-to-Age Factors					
Proportional	0.16	0.12	0.08	0.06	0.05	0.02
Non-Proportional and Facultative	1.53	0.30	0.15	0.40	0.05	0.07
	Standard Deviation - Paid Age-to-Age Factors					
Proportional	0.83	0.39	0.20	0.10	0.04	0.01
Non-Proportional and Facultative	37.77	0.35	0.39	0.15	0.20	0.11
	Absolute Difference - Reported Age-to-Age Factors					
Proportional	0.499	0.348	0.239	0.176	0.127	0.056
Non-Proportional and Facultative	4.837	0.953	0.420	1.117	0.140	0.163
	Absolute Difference - Paid Age-to-Age Factors					
Proportional	2.627	0.904	0.503	0.283	0.092	0.028
Non-Proportional and Facultative	116.571	1.179	1.110	0.380	0.502	0.250

Longer Reporting and Payment Patterns for Non-proportional versus Proportional Reinsurance

For this reinsurer, longer reporting and payment patterns are readily seen in Exhibit II, Sheet 5 when comparing proportional treaty to non-proportional treaty and facultative reinsurance for liability. This is not unexpected given the delays associated with non-proportional reinsurance and the long-tail nature of liability coverage. The reader is again cautioned about the simplistic process used for selecting tail factors in the examples of this chapter.

Variability in Ratios of Paid-to-Reported Losses

Many actuaries use development triangles for diagnostic purposes so that they can better understand how changes in operations and the external environment influence the loss data. Given the absence of data for claim counts and units of exposure for reinsurance, the ratio of paid-to-reported losses is one of the few triangle diagnostics that an actuary can review.

Examining the consistency of paid losses relative to reported losses is important for testing whether there might have been changes in case outstanding adequacy or in settlement patterns. Because this diagnostic is a ratio, further investigation is required if any changes are observed to determine if the change is occurring in paid losses (i.e., the numerator) or in the case outstanding, which are a critical component of the reported losses (i.e., the denominator). It is important to recognize that the absence of observed change in these ratios does not necessarily mean that changes are not occurring. There

could be offsetting changes in both claim settlement practices and the adequacy of case outstanding that result in no change to the ratios of paid-to-reported losses.

Table 3. 7 presents the ratios of paid-to-reported losses for the liability reinsurance example. The two measures of variability are shown for these ratios below each triangle. There is significantly more variability seen at all maturity ages from 12 months through 72 months in the ratios for non-proportional and facultative reinsurance than for proportional reinsurance.

Table 3. 7. Liability Reinsurance
Ratios of Paid-to Reported Losses

Treaty	Ratios Paid-to-Reported Losses as of (months)									
Year	12	24	36	48	60	72	84	96	108	120
	Liability - Proportional									
1	0.22	0.28	0.50	0.54	0.61	0.71	0.78	0.84	0.86	0.85
2	0.20	0.34	0.46	0.51	0.65	0.72	0.77	0.83	0.87	
3	0.18	0.31	0.44	0.52	0.66	0.73	0.81	0.87		
4	0.20	0.34	0.45	0.55	0.66	0.74	0.81			
5	0.20	0.39	0.47	0.62	0.67	0.75				
6	0.20	0.30	0.48	0.60	0.68					
7	0.19	0.29	0.45	0.58						
8	0.20	0.28	0.44							
9	0.18	0.30								
10	0.20									
Std Dev	0.01	0.03	0.02	0.04	0.02	0.02				
Abs Diff	0.044	0.108	0.058	0.108	0.072	0.040				
	Liability - Non-Proportional and Facultative									
1	0.19	0.18	0.36	0.38	0.29	0.34	0.35	0.78	0.81	0.81
2	0.22	0.15	0.32	0.50	0.60	0.61	0.64	0.66	0.74	
3	0.14	0.23	0.36	0.52	0.53	0.54	0.60	0.66		
4	0.04	0.15	0.30	0.44	0.53	0.66	0.68			
5	0.13	0.19	0.32	0.44	0.51	0.71				
6	0.13	0.15	0.31	0.36	0.49					
7	0.18	0.19	0.33	0.49						
8	0.13	0.31	0.34							
9	0.02	0.30								
10	0.26									
Std Dev	0.07	0.06	0.02	0.06	0.11	0.15				
Abs Diff	0.245	0.160	0.061	0.156	0.315	0.371				

The same drivers of greater volatility in age-to-age factors for non-proportional and facultative reinsurance versus proportional reinsurance can drive the greater volatility in ratios of paid-to-reported losses. It is important to recognize that the volatility in the age-to-age factors and the diagnostics can contribute to overall greater uncertainty in the selection of age-to-age factors. This can then lead to uncertainty in the projected ultimate losses derived from the development method. In turn, this can

lead to greater uncertainty in projections of ultimate losses from other methods, as they are often dependent on input from the development method.

Premium Development

A written premium development triangle was constructed to demonstrate how reinsurance premiums aggregated by treaty year can develop over time. Premium development is more pronounced for risks attaching reinsurance but also varies from one reinsurer to another depending on the distribution of renewal dates during the year. (See description of underwriting year in Chapter 1.) The ultimate losses for treaty years in which the premium is not fully earned require an adjustment to reflect only the portion of ultimate losses that are associated with occurrences prior to the valuation date. Exhibit II, Sheet 9 presents the premium development triangle, age-to-age factors, cumulative development factors, and projection of ultimate written premium by treaty year.

Concluding Remarks

The greater volatility and longer loss development patterns should not be surprising given that proportional reinsurance attaches on a ground-up basis, whereas non-proportional reinsurance is excess of loss coverage. Furthermore, there are many different types of non-proportional reinsurance, including excess per risk, excess per occurrence, catastrophe cover, and aggregate stop-loss. Each of these types of reinsurance could produce very different development patterns, none of which would be expected to be similar to or as stable as ground-up losses. While this example presents non-proportional treaty and facultative on a combined basis, the actuary would consider whether analysis with more segmented data would be appropriate.

Property Reinsurance excluding Catastrophe and Property Reinsurance Catastrophe

The next example compares the volatility in the age-to-age factors for property reinsurance excluding catastrophe and property reinsurance catastrophe. The property triangles include both treaty and facultative reinsurance, proportional and non-proportional, as well as personal and commercial lines of business. While in practice, these different types of risks would not be combined for detailed actuarial analyses of unpaid losses, the observed relationships are still important for understanding the volatility in this major line of business.

Catastrophe and Large Loss Events

Many actuaries exclude unusually large losses arising from catastrophe and other large loss events from development triangles, as such losses can significantly distort development factors and resulting estimates of unpaid losses. For reinsurers, carried reserves for these types of events tend not to be based on aggregated development analyses but instead on ground-up exposure-based assessments that reflect information provided by ceding companies on a contract-by-contract basis. Actuaries may supplement information from claims professionals with results from catastrophe models, particularly in the time period immediately following a catastrophe event when claims teams may not have access to the affected area.

In this example, losses associated with catastrophe events are included in the development triangle for property catastrophe reinsurance. Observe the tremendous volatility in losses down each column of the reported loss triangle, which is presented in Exhibit III, Sheet 2 and in Table 3. 8. The label "net reported losses" in this example refers to losses that are net of retrocessions.

Table 3. 8. Property Reinsurance Catastrophe – Reported Losses

Treaty	Net Reported Losses as of (months)									
Year	12	24	36	48	60	72	84	96	108	120
1	13,440	30,393	31,135	31,714	32,019	32,358	32,523	32,577	32,482	32,467
2	2,905	4,172	4,024	3,966	3,944	3,910	3,890	3,905	3,914	
3	4,240	6,040	6,416	6,282	6,343	6,715	6,645	6,600		
4	13,080	14,350	16,228	16,786	16,807	16,806	16,742			
5	4,892	9,050	9,448	9,066	8,963	8,912				
6	5,531	44,749	55,431	57,542	59,903					
7	10,150	13,806	14,332	16,540						
8	1,546	4,184	4,211							
9	15,554	18,677								
10	920									

The reported losses at 12 months range from a low of 920 to a high of 15,554; at 24 months, the reported losses range from a low of 4,172 to a high of 44,749. Great variability is seen down each column of the triangle.

The loss development seen in triangles can be distorted by the timing of catastrophe events as well as the wide swings in losses associated with such events. For example, one year may have a catastrophic ice storm in January that is almost fully developed by year-end (i.e., December 31), and the following year may have a late season hurricane that occurs the first week of December. The extent of claims reporting and settlement will be completely different for these two events as of December 31 (i.e., as of 12 months in a development triangle), and thus the loss development seen from 12-to-24 months will be completely different. The situation could be further exacerbated with treaties that are risks-attaching, where catastrophe events associated with a treaty year could occur within a time frame of up to three years. (See discussion of underwriting year in Chapter 2.) This could be a driver of the significant differences from 12-to-24 months for treaty years 6 and 7 (i.e., catastrophe events at significantly different times of the treaty year).

The fundamental assumption of the development method is that the relative change in a given year's losses from one evaluation point to the next is similar to the relative change in prior years' losses at similar evaluation points. This assumption may not always be appropriate for property reinsurance catastrophe.

Comparison of Volatility in Age-to-Age Factors

The reported and paid loss triangles (including age-to-age factors, average age-to-age factors, and cumulative development factors) are seen in Exhibit III, Sheets 1–4. Reporting and payment patterns are seen in Exhibit III, Sheet 5.

As with the prior examples, the standard deviations and absolute differences of age-to-age factors are calculated for each age interval from 12-to-24 months through 72-to-84 months. The measures of variability are shown in Table 3. 9.

Table 3. 9. Property Reinsurance
Measures of Variability in the Age-to-Age Factors

	Age-to-Age Interval					
	12-24	24-36	36-48	48-60	60-72	72-84
	Standard Deviation - Reported Age-to-Age Factors					
Property Reinsurance excluding Catastrophe	0.66	0.05	0.03	0.01	0.00	0.00
Property Reinsurance Catastrophe	2.20	0.09	0.06	0.02	0.03	0.01
	Standard Deviation - Paid Age-to-Age Factors					
Property Reinsurance excluding Catastrophe	2.23	0.09	0.04	0.01	0.02	0.00
Property Reinsurance Catastrophe	6.24	0.12	0.13	0.02	0.04	0.03
	Absolute Difference - Reported Age-to-Age Factors					
Property Reinsurance excluding Catastrophe	1.804	0.162	0.083	0.024	0.011	0.006
Property Reinsurance Catastrophe	6.993	0.274	0.194	0.052	0.067	0.016
	Absolute Difference - Paid Age-to-Age Factors					
Property Reinsurance excluding Catastrophe	7.476	0.233	0.111	0.020	0.040	0.008
Property Reinsurance Catastrophe	19.671	0.355	0.357	0.059	0.082	0.065

The volatility is substantially higher for catastrophe reinsurance than for property excluding catastrophe reinsurance for both reported and paid losses. This is not surprising given the nature of catastrophes, both natural and man-made. Greater variability is also seen in the ratios of paid-to-reported losses that are presented in Table 3. 10.

Table 3. 10. Property Reinsurance
Ratios of Paid-to Reported Losses

Treaty	Ratios Paid-to-Reported Losses as of (months)									
Year	12	24	36	48	60	72	84	96	108	120
	Property Reinsurance excluding Catastrophe									
1	0.28	0.61	0.84	0.91	0.94	0.98	0.99	0.99	0.99	1.00
2	0.30	0.60	0.82	0.90	0.95	0.97	0.97	0.98	0.98	
3	0.26	0.61	0.79	0.90	0.96	0.98	0.99	0.99		
4	0.21	0.65	0.83	0.93	0.96	0.97	0.99			
5	0.26	0.57	0.82	0.92	0.96	0.98				
6	0.33	0.54	0.78	0.91	0.95					
7	0.30	0.64	0.77	0.91						
8	0.28	0.57	0.77							
9	0.32	0.67								
10	0.39									
Std Dev	0.05	0.04	0.03	0.01	0.01	0.01				
Abs Diff	0.188	0.126	0.069	0.037	0.019	0.016				
	Property Reinsurance Catastrophe									
1	0.16	0.68	0.92	0.97	0.97	1.04	0.99	0.99	1.00	1.00
2	0.13	0.65	0.87	0.92	0.95	0.97	0.98	0.98	0.98	
3	0.51	0.74	0.88	0.94	0.95	0.94	0.97	0.98		
4	0.31	0.72	0.80	0.91	0.98	0.98	0.99			
5	0.16	0.65	0.81	0.92	0.96	0.97				
6	0.24	0.62	0.79	0.89	0.91					
7	0.22	0.45	0.63	0.76						
8	0.55	0.61	0.75							
9	0.73	0.83								
10	0.19									
Std Dev	0.21	0.11	0.09	0.07	0.02	0.04				
Abs Diff	0.599	0.388	0.295	0.209	0.065	0.104				

Given the significant volatility evident in the property reinsurance catastrophe loss development triangle, methods that rely on selected age-to-age factors are often not appropriate. Instead, actuaries can turn to catastrophe models and discussions with claims professionals. Catastrophe models can be particularly valuable for catastrophe events that occur close to a financial reporting date in circumstances where an insurer (or reinsurer) has not had time to process many claims. This assumes that the catastrophe event lends itself to reliable catastrophe modeling (such as hurricanes and earthquakes). As time progresses and the insurer (or reinsurer) has time to deploy claims adjusters on site and begin to process claims, the insight from the claims team will be invaluable to the actuary estimating unpaid losses.

Table 3. 11 presents an alternative for the projection of ultimate losses using the development method for property catastrophe reinsurance. In this approach, the losses associated with specific catastrophes

are excluded from the calculation and replaced with estimates derived from interaction with the claims team and review of indications from catastrophe models.

Table 3. 11. Alternative Projection with Adjustments for Large Catastrophes

Treaty Year	Losses at 12/31/10		Catastrophe Losses at 12/31/10			Cum Dev Factor at 12/31/10		Projected Ultimate Losses with Cat Adj Based on		Projected Ultimate Losses without Cat Adj Based on	
	Reported	Paid	Reported	Paid	Estimated Ultimate	Reported	Paid	Reported	Paid	Reported	Paid
1	32,467	32,438	28,500	28,500	28,500	1.000	1.010	32,465	32,477	32,452	32,762
2	3,914	3,817	-	-	-	0.999	1.010	3,910	3,856	3,910	3,856
3	6,600	6,443	-	-	-	0.997	1.012	6,578	6,520	6,578	6,520
4	16,742	16,563	-	-	-	0.997	1.016	16,696	16,835	16,696	16,835
5	8,912	8,647	-	-	-	0.997	0.994	8,889	8,596	8,889	8,596
6	59,903	54,576	50,000	49,000	50,500	1.007	1.042	60,469	56,309	60,299	56,853
7	16,540	12,558	-	-	-	1.032	1.100	17,062	13,811	17,062	13,811
8	4,211	3,167	-	-	-	1.076	1.297	4,530	4,108	4,530	4,108
9	18,677	15,577	13,000	8,900	20,000	1.244	1.898	27,065	32,670	23,242	29,558
10	920	179	-	-	-	2.988	6.626	2,749	1,186	2,749	1,186
Total	168,886	153,965	91,500	86,400	99,000			180,413	176,368	176,409	174,086

The mathematics of the projected ultimate losses with catastrophe adjustment are as follows:

- [(Reported losses – catastrophe reported losses) x reported cumulative development factor + estimated ultimate catastrophe losses].
- [(Paid losses – catastrophe paid losses) x paid cumulative development factor + estimated ultimate catastrophe losses].

The projected ultimate losses from the standard application of the development method are seen in the last two columns of Table 3. 11. There are notable differences in the indicated IBNR for treaty year 9 between the projections with and without adjustment for catastrophe. Another option that the actuary could consider is deriving separate development patterns from data inclusive and exclusive of years with unusually large catastrophe events.

Implications of Volatility in Loss Development Experience

Greater volatility in age-to-age factors can lead to greater uncertainty in the projections of ultimate losses and the resulting estimates of unpaid losses, not only for projections based on the development method but also projections based on other frequently used methods. Actuaries often use estimates of ultimate losses from the development method for mature years to determine the expected loss ratios used in the expected method. Thus, volatility in the age-to-age factors can result in uncertainty in the projections of the development method, which can lead to uncertainty in the selection of the expected loss ratio. The Bornhuetter-Ferguson method relies on the selected development patterns and the expected loss estimates. Thus, volatility and uncertainty in these can lead to uncertainty in the Bornhuetter-Ferguson projections of ultimate losses. Professional judgment is critically important for actuaries estimating unpaid losses for reinsurance.

The examples continue in Sheets 6–8 of the exhibits at the end of the chapter for:

- Professional lines – primary insurance and reinsurance.
- Liability – proportional treaty reinsurance and non-proportional treaty and facultative reinsurance.
- Property – reinsurance excluding catastrophe and reinsurance catastrophe.

Sheet 6 shows the development of the expected loss ratios. Sheet 7 presents the results of the expected method and the Bornhuetter-Ferguson method with reported and paid losses. Finally, Sheet 8 shows indicated IBNR and total unpaid losses.

Details of the calculations are assumed to be known and thus are not included. (For more information, see *Estimating Unpaid Claims Using Basic Techniques*.) One important difference with primary insurance and reinsurance is the need to earn the premium when analyses are conducted using treaty year data. For the liability and property examples, where data are aggregated by treaty year, the expected loss ratios are developed for the complete treaty year; similarly, ultimate losses are developed for the full treaty year for all years in the experience period. On Sheet 8 of Exhibits II and III, an adjustment is made for the most recent treaty years to reduce ultimate losses for the portion of premium unearned as of the valuation date (i.e., December 31, 10).

Observations

In Sheet 6, where expected loss ratios are selected, the standard deviation and absolute difference of the indicated ultimate loss ratios are calculated for each category of business. Similar to the greater volatility observed in age-to-age factors, greater volatility is also seen in the indicated ultimate loss ratios. Table 3. 12 summarizes the standard deviations and absolute differences for the above examples.

Table 3. 12. Measures of Variability in the Indicated Ultimate Loss Ratios

	Standard Deviation	Absolute Difference
Professional Lines - Primary Insurance	0.04	13%
Professional Lines - Reinsurance	0.14	41%
Liability Proportional Treaty Reinsurance	0.08	23%
Liability Nonproportional Treaty and Facultative Reinsurance	0.14	44%
Property excluding Catastrophe Reinsurance	0.17	51%
Property Catastrophe Reinsurance	0.64	157%

Range of Indicated IBNR and Total Unpaid

Calculations are extended to project ultimate losses with the development method (with reported and paid losses), the expected method, and the Bornhuetter-Ferguson method (also with reported and paid losses). The indicated IBNR and total unpaid losses are then calculated. Indicated IBNR is equal to the projected ultimate losses less total reported losses, and total unpaid losses are equal to the projected ultimate losses less total paid losses.

Sheet 8 presents the projected ultimate losses from each method by year (with adjustment for earning of the premium where losses are aggregated by treaty year) and the indicated IBNR and total unpaid losses resulting from each method on a total all years combined basis.

Not surprisingly, there is a greater range of indicated IBNR as measured by the maximum value minus the minimum value for reinsurance than for primary insurance in the professional lines example, for non-proportional treaty than proportional and facultative reinsurance than for proportional treaty reinsurance in the liability example, and for catastrophe than excluding catastrophe for the property reinsurance example.

Quota Share and Stop-Loss Reinsurance Examples

The final two examples in this chapter are from the perspective of the ceding company (i.e., the reinsured). They expand on the example of GL Self-Insurer found in *Estimating Unpaid Claims Using*

Basic Techniques.[51] For purposes of this reinsurance text, GL Self-Insurer is presented as GL Captive Insurer since captive insurers routinely purchase reinsurance.

Quota Share Reinsurance

Recall that with proportional reinsurance, the reinsurer shares the experience of the ceding company from the ground-up. For quota share, where premiums and losses are shared based on a specified percentage, the age-to-age factors are identical for losses gross of reinsurance, ceded losses, and losses net of reinsurance.[52]

With quota share reinsurance, the ceded losses are equal to gross losses multiplied by the percentage ceded. It is very important to understand the meaning of the percentage cited for quota share reinsurance, as the percentage can be used to refer to the percentage ceded or the percentage retained. The actuary should always seek clarification to ensure proper application of the percentage.

For a ceding company, the estimation of ultimate losses and unpaid losses for a line of business with a quota share reinsurance treaty is often a straightforward calculation. The percentage ceded is applied to the ultimate losses, case reserves, paid losses, and IBNR to determine the losses ceded to the reinsurer. If the percentage ceded remains constant for all years in the experience period, the calculation can be performed on a total basis for all years combined. Frequently, the percentage ceded changes over time, and the calculations are performed by year.

Table 3. 13 presents an example where the quota share reinsurance percentages are assumed to vary by year. (Note "QS" is used in a column heading as an abbreviation for quota share.) For GL Captive Insurer, accident year is equivalent to policy year as there is a single policy with a January 1 effective date. In this example, the quota share percentages are presented as the percentage ceded by GL Captive Insurer.

[51] The reported and paid losses are from Chapter 8 of *Estimating Unpaid Claims Using Basic Techniques, and t*he selected ultimate losses are assumed equal to the reported development projection.

[52] Surplus share reinsurance differs from quota share, and thus differences in age-to-age factors would exist due to the variable nature of the percentage of losses shared in surplus share reinsurance. However, the differences are likely not nearly as pronounced as they are between proportional and non-proportional reinsurance.

Table 3. 13. GL Captive Insurer – Example of the Application of Quota Share Reinsurance from the Ceding Company's Perspective Development of Losses ($000s) Ceded to Quota Share Reinsurance at December 31, 11

	Gross of Quota Share Reinsurance					Ceded to Quota Share Reinsurance					Retained
	Selected	At December 31, 11				At December 31, 11					Ultimate
Accident	Ultimate	Paid	Case	Indicated	QS %		Case		Total		Losses
Year	Losses	Losses	Oustanding	IBNR	Ceded	Paid	Oustanding	IBNR	Unpaid	Ultimate	After QS
1	914	890	10	14	50%	445	5	7	12	457	457
2	1,224	1,170	30	24	50%	585	15	12	27	612	612
3	1,339	1,265	35	39	50%	633	18	20	37	670	670
4	1,892	1,600	200	92	50%	800	100	46	146	946	946
5	1,562	1,200	250	112	40%	480	100	45	145	625	937
6	1,583	1,050	350	183	35%	368	123	64	187	554	1,029
7	2,986	900	1,500	586	30%	270	450	176	626	896	2,090
8	2,509	860	940	709	25%	215	235	177	412	627	1,882
9	2,424	525	975	924	20%	105	195	185	380	485	1,939
10	2,328	750	450	1,128	20%	150	90	226	316	466	1,862
11	1,862	170	430	1,262	15%	26	65	189	254	279	1,583
Total	20,623	10,380	5,170	5,073		4,076	1,395	1,146	2,541	6,616	14,007

The calculations above would likely not be the same for an actuary working with a primary insurer or a reinsurer. For a primary insurer, the calculations can become complicated if the quota share coverage is from a risks-attaching reinsurance treaty with a ceded percentage that changes over time and the reserving analysis of gross results is prepared on an accident year basis. In this situation, the change in the ceded percentage applies based on the policy year of the underlying risks not on the accident year of the insured event. For a reinsurer, there would be numerous quota share treaties in a single HRG with different ceding percentages and different terms and conditions, and thus the previous simple calculation would not be applicable.

Stop-Loss Reinsurance

The example with GL Captive Insurer continues with stop-loss coverage where the quota share arrangement inures to the benefit of the stop-loss coverage. Table 3. 14 presents the results, which are described after the table.

Table 3. 14. GL Captive Insurer – Example of the Application of Stop-Loss Limits from the Ceding Company's Perspective

Accident Year	Retained Ult Losses After QS	Stop-Loss Limit	Retained Ult Losses After QS and Stop Loss	Losses at December 31, 11 Net of Quota Share and Stop Loss			
				Reported	Paid	Case O/S	IBNR
1	457	750	457	450	445	5	7
2	612	750	612	600	585	15	12
3	670	750	670	650	633	18	20
4	946	750	750	750	750	-	-
5	937	750	750	750	720	30	-
6	1,029	1,500	1,029	910	683	228	119
7	2,090	1,500	1,500	1,500	630	870	-
8	1,882	3,000	1,882	1,350	645	705	532
9	1,939	3,000	1,939	1,200	420	780	739
10	1,862	3,000	1,862	960	600	360	902
11	1,583	3,000	1,583	510	145	366	1,073
Total	14,007		13,034	9,630	6,255	3,376	3,404

The retained ultimate losses after quota share are derived from Table 3. 13 and are equal to ultimate losses gross of quota share minus ultimate losses ceded to quota share. Ultimate losses after quota share can also be calculated as ultimate losses gross of quota share multiplied by 1.0 minus the quota share ceded percentage. Stop-loss limits are assumed for the purpose of this example.

Retained ultimate losses after quota share and stop-loss are calculated as:

Minimum [retained ultimate losses after quota share, stop-loss limit].

Reported and paid losses after quota share and stop-loss are calculated in a similar way. Observe that reported and paid losses for accident year 4 are both capped by the stop-loss limit of 750, and there is nil case outstanding and nil IBNR after quota share and stop-loss. For accident year 5, the reported losses are capped but the paid losses are not, and thus there is case outstanding of 30 net of quota share and stop-loss; however, there is no net IBNR for accident year 5. Similar observations are made for accident year 7, where reported losses are capped by the stop-loss of 1500 but the paid losses are not, and case outstanding are 870 with no IBNR.

In practice, once a ceding company breaches stop-loss coverage, it is not uncommon for the reinsurer to increase the price or the attachment point of stop-loss reinsurance (or both). Depending on market conditions, stop-loss reinsurance can be extremely challenging to secure after the ceding company exceeds its retention on more than one occasion.

In this example, the reported losses for accident year 7 of 2,400 (sum of paid losses of 900 and case outstanding of 1,500) are significantly greater than all other accident years. (See Table 3.13 for details by accident year.) Assume that there is an individual large loss for this accident year with an estimated ultimate value of 500. Further assume that GL Captive Insurer has excess per occurrence reinsurance with an attachment point of 100 that inures to the benefit of the quota share and stop-loss coverages. The ultimate loss gross and net of all reinsurance coverage is calculated as shown in Table 3. 15.

Table 3. 15. GL Self-Insurer – Accident Year Losses Net of Excess Per Occurrence, Quota Share, and Stop-Loss Reinsurance

(1) Selected ultimate loss gross of all reinsurance	2,986
(2) Single large loss	500
(3) Excess per occurrence reinsurance - attachment point	100
(4) Ceded losses to excess per occurrence reinsurer (4) = [(2) - (3)]	400
(5) Ultimate losses net of excess per occurrence reinsurance (5) = [(1) - (4)]	2,586
(6) Quota share ceded percentage	30%
(7) Ultimate losses net of excess per occurrend and quota share reinsurance (7) = [(5) x (1.0 - (6))]	1,810
(8) Stop loss limit	1,500
(9) Ultimate losses net of all reinsurance (9) = minimum [(7), (8)]	1,500

In this example, the loss ceded to the excess per occurrence reinsurance is first removed from the results before the application of the quota share ceded percentage. The ultimate losses net of quota share are then determined with the application of the stop-loss limit as the final step. Stop-loss limits typically apply after all other reinsurance. This form of reinsurance is used to protect the net result of the ceding company.

It is very important for the actuary to have complete details about the types of reinsurance (including attachment points, limits, participation percentages, and treatment of LAE) as well as the order in which different reinsurance contracts are applied. The determination of ceded losses can be a very complex process, and it is critical for the actuary to understand and clearly document the calculations and assumptions.

Conclusion

The estimation of ultimate losses and unpaid losses is a critical task of actuaries working with insurance and reinsurance. While the methods described in this chapter are used extensively, they should not be used mechanically without supplementing with professional judgment. Actuaries should meet regularly with underwriting teams and claims personnel to ensure that as much information as possible is considered before final decisions are made about the reserves to book in financial statements. Without incorporating critical insight from others, results derived from mechanical application of the development, expected, and Bornhuetter-Ferguson methods could produce inappropriate results.