Casualty Actuarial Society

Basic Ratemaking

Geoff Werner, FCAS, MAAA
Claudine Modlin, FCAS, MAAA
EMB

With significant contributions by other EMB associates: Alice Gannon, FCAS, MAAA; Serhat Guven, FCAS, MAAA; Christine Gennett, ACAS, MAAA; Jeff Kucera, FCAS, MAAA; Brett Nunes, ASA, MAAA; and Dave Otto, FCAS, MAAA

Fourth Edition, October 2010

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VERSION 4, OCTOBER 2010

This text outlines basic property/casualty insurance ratemaking concepts and techniques. It is intended to be a single educational text to prepare actuarial candidates practicing around the world for basic ratemaking. A key concept in the text is the fundamental insurance equation, which balances the expected future income and outgo of an insurance operation. Various chapters discuss the individual components of the equation (e.g., premium, loss, expense, profit), and other chapters review how to assess whether the equation is in balance in the aggregate and by customer segment. The text focuses on quantitative analysis as well as practical considerations in the ratemaking process. Finally, the text provides consistent definitions of terms and examples that underlie the ratemaking techniques discussed.

FOREWORD

Ratemaking is a key driver of property and casualty (P&C) insurance profitability and hence a primary actuarial responsibility. Actuaries employ a variety of ratemaking techniques depending on specific circumstances. For example, techniques used to price short-tailed lines of insurance (e.g., personal automobile) are different than techniques used in long-tailed lines (e.g., workers compensation). Even within the same insurance product, actuarial techniques may differ due to regulatory requirements and data limitations. Furthermore, actuarial techniques are constantly evolving due to enhanced information and advances in technology.

This text is not intended to document every technique used for P&C insurance ratemaking. Instead, the purpose of this text is to provide an overview of basic ratemaking techniques used in the industry. As such, actuaries should continue to increase the depth and breadth of their knowledge to be able to discern the most appropriate technique for a given situation.

ACKNOWLEDGMENTS

The completion of this text required significant effort from many individuals other than the primary authors. The authors want to acknowledge the following individuals for researching and summarizing existing ratemaking material, offering alternative ratemaking techniques, and reviewing countless drafts:

> Catherine Taylor, FCAS, MAAA and her CAS committee, comprised of Nancy Braithwaite, FCAS, MAAA; Ginda Fisher, FCAS, MAAA; Chris Styrsky, FCAS, MAAA; Jane Taylor, FCAS, MAAA; Theresa Turnacioglu, FCAS, MAAA; and Ron Zaleski, Jr., FCAS, MAAA, dedicated to partnering with EMB to facilitate the successful completion of this text.
>
> The following associates of EMB: Tom Hettinger, ACAS, MAAA; David Sommer, FCAS; Emily Stoll, ACAS, MAAA; Julie Walker, ACAS, MAAA; Sandy Wu, ACAS, MAAA; Harsha Maddipati; and Peter Quackenbush.
>
> The following actuaries who were consulted for their expertise in specific ratemaking topics: Joseph Palmer, FCAS, MAAA; James Guszcza, FCAS, MAAA; and Will Davis, FCAS, MAAA.
>
> All of the authors who developed the materials from the prior Ratemaking examination; EMB relied heavily upon that material when creating this text.
>
> Howard Mahler, FCAS, MAAA for his valuable contributions to subsequent versions of the text.

REFERENCE MATERIAL

The objective of the CAS in creating a new basic ratemaking text was to replace the series of readings that existed on the syllabus of basic education as of 2007 with a single educational publication. As such, the authors relied heavily on a series of published articles and texts that are contained in the Bibliography at the end of the text. Specific references to each of these sources are also present in individual chapters.

ROUNDING

Rounding procedures have been applied in a manner consistent with the number of decimals shown in the text and tables (or per rounding procedures specifically outlined in the text). Small discrepancies may exist between the text and table entries when the text is summarizing multiple calculations within a table or further dissecting calculations in a table for illustrative purposes.

ORGANIZATION OF THIS TEXT

This text is organized into sixteen chapters plus six appendices. The chapters discuss various ratemaking concepts and techniques, and provide simple examples. Each chapter concludes with a narrative summary as well as an outline of key concepts covered in the chapter. The appendices provide in-depth practical examples of some of the techniques discussed throughout the text. In order to reinforce the concepts and techniques discussed in the body of the text, the authors suggest Appendices A-D be read upon completion of Chapter 8, and Appendices E-F be read upon completion of Chapters 9-10.

Below is a summary of the content of each chapter and appendix.

Chapter 1 provides an overview of P&C insurance ratemaking, highlighting the unique relationship between price, cost, and profit. This overview includes basic P&C insurance terms and commonly used insurance ratios. This chapter also introduces the fundamental insurance equation, a key concept that is referenced frequently in other chapters. This concept states that premium charged for policies written during a future time period should be appropriate to cover the losses and expenses expected for those policies while achieving the targeted profit.

Chapter 2 discusses the P&C insurer rating manual, an aid for anyone who needs to understand the process of calculating an insurance premium. The four main components of P&C insurer rating manuals are rules, rate pages, rating algorithms, and underwriting guidelines. The chapter also includes three rating manual examples for different insurance lines of business.

Chapter 3 discusses ratemaking data, both internal and external to the insurance company, and introduces methods of data organization. An example of internal data requirements is provided, as well as sources of external data.

Chapter 4 discusses insurance exposures, the basic unit that measures a policy's exposure to loss and therefore serves as the basis for the calculation of premium. The chapter outlines criteria for selecting exposure bases, methods and quantitative examples for defining and aggregating exposures, and circumstances requiring a measurement of exposure trend.

Chapter 5 focuses on premium, the price the insured pays for the insurance product and one of the key elements of the fundamental insurance equation. The chapter discusses different ways to define and aggregate premium (including quantitative examples) and introduces standard techniques to adjust historical premium data to make it relevant for estimating future premium in the context of ratemaking. These adjustments include current rate level, premium development in consideration of premium audits, and premium trend. These adjustments to premium are relevant in loss ratio analysis.

Chapter 6 is dedicated to losses and loss adjustment expenses. Losses are amounts paid or owed to claimants under the provisions of the insurance contract. This chapter outlines the different types of insurance losses, reviews how loss data is aggregated for ratemaking analysis, and defines common metrics involving losses. This chapter also describes the various adjustments to historical loss data to make it relevant for estimating future losses. These include adjustments for extraordinary events, changes in benefit levels, changes in loss estimates as claims mature, and changes in cost levels over time. Finally, the chapter discusses the treatment of loss adjustment expenses in ratemaking.

Chapter 7 covers methods for projecting underwriting expenses and addresses how to incorporate the cost of reinsurance and an underwriting profit provision in the rates.

Chapter 8 demonstrates how to combine the various estimated components of the fundamental insurance equation (i.e., premium, loss, expense) to ascertain the appropriate overall rate level (or rate level change) for the future policy period. The two overall rate level methods discussed are the pure premium and loss ratio methods. The methods are mathematically equivalent, but each offers advantages and disadvantages in certain circumstances.

Chapter 9 covers rate adequacy at the individual risk (or risk segment) level. The chapter discusses the concept of risk segmentation via rating variables and outlines criteria to consider when using a certain risk characteristic as a rating variable. The chapter also reviews the application of univariate methods to historical data to calculate rate differentials (or changes to existing rate differentials) for each rating variable. This process is known as classification ratemaking.

Chapter 10 is an extension of Chapter 9 that specifically addresses multivariate classification ratemaking techniques. The chapter discusses the benefits of multivariate approaches and provides a basic explanation of the mathematical foundation of one commonly used multivariate method, generalized linear models (GLMs). Sample output with explanation is provided for GLM results as well as associated statistical diagnostics. The chapter also reviews some commonly used data mining techniques.

Chapter 11 addresses additional classification ratemaking techniques that were developed to address the unique qualities of some rating variables or risk characteristics. These include territory boundary analysis, increased limits factors, deductibles, size of risk for workers compensation insurance, and the concept of insurance to value and how it affects the adequacy of rates.

Chapter 12 provides a broad overview of the credibility procedures used in ratemaking. This includes methods for incorporating credibility in an actuarial estimate, desirable qualities for the complement of credibility (the related data that is blended with the original actuarial estimate), and methods and examples for determining the complement of credibility.

Chapter 13 explores other items company management should consider, along with the actuarial indications discussed in the previous chapters, to determine what rates to charge in practice. These considerations include regulatory constraints, operational constraints, and market conditions.

Chapter 14 discusses non-pricing and pricing solutions to an imbalanced fundamental insurance equation (i.e., current rates do not produce an average premium that is equivalent to the sum of expected costs and target underwriting profit). In regards to pricing solutions, the chapter discusses how to calculate final rates for an existing product, as well as how to develop rates for a new product by referencing other data sources. The chapter concludes with comments regarding the importance of communicating expected rate change results to key stakeholders and monitoring results after implementation.

Chapter 15 covers additional ratemaking methods commonly used by commercial insurers. The methods are divided into two categories: those that alter the rate calculated from the rating manual and those that are employed by insurers to calculate a premium unique to a particular large commercial risk. The former category includes experience rating and schedule rating, and the latter category includes loss-rated composite risks, large deductible policies, and retrospective rating.

Chapter 16 discusses the adoption of claims-made policies, with particular attention to the medical malpractice line of business. This alternative to occurrence policies shortens the time period from coverage inception to claim settlement. For the ratemaking actuary, this translates to a shorter forecast period and therefore reduced pricing risk.

Appendices A-D provide illustrative examples of overall rate level analyses for personal automobile, homeowners, medical malpractice, and workers compensation lines of business. The examples incorporate many of the ratemaking concepts and techniques discussed in Chapters 1-8.

Appendices E-F provide illustrative examples of classification ratemaking analysis using the univariate and multivariate techniques discussed in Chapters 9 and 10, respectively.

TEXT NOTATION

The text contains a significant number of formulae. The following is a summary of the key notation that appears throughout the text. Actual references in the text may specify more precise definitions (e.g., L could be used to describe accident year reported losses, policy year ultimate losses, etc.).

X = Exposures

$P; \overline{P}$ = Premium; Average premium (P divided by X)

$P_c; \overline{P_c}$ = Premium at current rates; Average premium at current rates (P_C divided by X)

$P_I; \overline{P_I}$ = Indicated premium; Average indicated premium (P_I divided by X)

$P_P; \overline{P_P}$ = Premium at proposed rates; Average premium at proposed rates (P_P divided by X)

$L; \overline{L}$ = Losses; Pure Premium (L divided by X)

$E_L; \overline{E_L}$ = Loss Adjustment Expense (LAE); Average LAE per exposure (E_L divided by X)

$E_F; \overline{E_F}$ = Fixed underwriting expenses; Average underwriting expense per exposure (E_F divided by X)

E_V = Variable underwriting expenses

F = Fixed expense ratio (E_F divided by P)

V = Variable expense provision (E_V divided by P)

Q_C = Profit percentage at current rates

Q_T = Target profit percentage

B_C = Current base rate

B_P = Proposed base rate

$R1_{C,i}$ = Current relativity for the i^{th} level of rating variable $R1$

$R1_{P,i}$ = Proposed relativity for the i^{th} level of rating variable $R1$

A_C = Current fixed additive fee

A_P = Proposed fixed additive fee

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CHAPTER 1: INTRODUCTION

In a free market society, an entity offering a product for sale should try to set a price at which the entity is willing to sell the product and the consumer is willing to purchase it. Determining the supplier-side price to charge for any given product is conceptually straightforward. The simplest model focuses on the idea that the price should reflect the costs associated with the product as well as incorporate an acceptable margin for profit. The following formula depicts this simple relationship between price, cost, and profit:

$$\text{Price} = \text{Cost} + \text{Profit}.$$

For many non-insurance goods and services, the production cost is known before the product is sold. Therefore, the initial price can be set so that the desired profit per unit of product will be achieved.

Insurance is different from most products as it is a promise to do something in the future if certain events take place during a specified time period. For example, insurance may be a promise to pay for the rebuilding of a home if it burns to the ground or to pay for medical treatment for a worker injured on the job. Unlike a can of soup, a pair of shoes, or a car, the ultimate cost of an insurance policy is not known at the time of the sale. This places the classic equation in a somewhat different context and introduces additional complexity into the process of price setting for an insurance company.

The purpose of this text is to outline the fundamentals of setting insurance prices, which is referred to as ratemaking in the property and casualty (P&C) insurance industry. In addition to the ratemaking concepts outlined in each chapter, the appendices to this text provide realistic numeric examples of ratemaking analysis.

RATING MANUALS

The price the insurance consumer pays is referred to as premium, and the premium is generally calculated based on a given rate per unit of risk exposed. Insurance premium can vary significantly for risks with different characteristics. The rating manual is the document that contains the information necessary to appropriately classify each risk and calculate the premium associated with that risk. The final output of the ratemaking process is the information necessary to modify existing rating manuals or create new ones.

The earliest rating manuals were very basic in nature and provided general guidelines to the person responsible for determining the premium to be charged. Over time, rating manuals have increased in complexity. For some lines, the manuals are now extremely complex and contain very detailed information necessary to calculate premium. Furthermore, many companies are creating manuals electronically in lieu of paper copies. Chapter 2 includes more detailed information and specific examples of rating manuals.

BASIC INSURANCE TERMS

This section provides a brief definition of terms that are fundamental to understanding insurance ratemaking. Chapters 3 through 7 provide more detailed definitions and address how such data is compiled and adjusted for ratemaking analysis.

Exposure

An **exposure** is the basic unit of risk that underlies the insurance premium. The exposure measure used for ratemaking purposes varies considerably by line of business. For example, one house insured for one year represents one exposure for homeowners insurance. Annual payroll in hundreds of dollars represents the typical exposure unit for U.S. workers compensation insurance. There are four different ways that insurers measure exposures: written, earned, unearned, and in-force exposures.

- **Written exposures** are the total exposures arising from policies issued (i.e., underwritten or written) during a specified period of time, such as a calendar year or quarter.
- **Earned exposures** represent the portion of the written exposures for which coverage has already been provided as of a certain point in time.
- **Unearned exposures** represent the portion of the written exposures for which coverage has not yet been provided as of that point in time.
- **In-force exposures** are the number of insured units that are exposed to loss at a given point in time.

Chapter 4 includes an example demonstrating the different exposure measures and how they are aggregated for ratemaking analysis.

Premium

Premium is the amount the insured pays for insurance coverage. The term can also be used to describe the aggregate amount a group of insureds pays over a period of time. Like exposures, there are written, earned, unearned, and in-force premium definitions.

- **Written premium** is the total premium associated with policies that were issued during a specified period.
- **Earned premium** represents the portion of the written premium for which coverage has already been provided as of a certain point in time.
- **Unearned premium** is the portion of the written premium for which coverage has yet to be provided as of a certain point in time.
- **In-force premium** is the full-term premium for policies that are in effect at a given point in time.

Chapter 5 includes an example demonstrating the different premium measures and how they are aggregated, as well as various adjustments to historical premium for ratemaking analysis.

Claim

An **insurance policy** involves the insured paying money (i.e., premium) to an insurer in exchange for a promise to indemnify the insured for the financial consequences of an event covered by the policy. If the event is covered by the policy, the insured (or other individual as provided in the insurance policy) makes a demand to the insurer for indemnification under the policy. The demand is called a **claim** and the individual making the demand is called a **claimant**. The claimant can be an insured or a third party alleging injuries or damages that are covered by the policy.

The date of the event that caused the loss is called the **date of loss** or **accident date** (also sometimes called **occurrence date**). For most lines of business and perils, the accident is a sudden event. For some lines and perils, the loss may be the result of continuous or repeated exposure to substantially the same general hazard conditions; in such cases, the accident date is often the date when the damage, or loss, is apparent. Until the claimant reports the claim to the insurer (i.e., the **report date**) the insurer is unaware of the claim. Claims not currently known by the insurer are referred to as **unreported claims** or **incurred but not reported (IBNR) claims**. After the report date, the claim is known to the company and is classified as a reported claim. Until the claim is settled, the reported claim is considered an open claim. Once the claim is settled, it is categorized as a closed claim. In some instances, further activity may occur after the claim is closed, and the claim may be re-opened.

Loss

Loss is the amount of compensation paid or payable to the claimant under the terms of the insurance policy. The actuarial community occasionally uses the terms losses and claims interchangeably. This text uses the term claim to refer to the demand for compensation, and loss to refer to the amount of compensation. This terminology is more common in ratemaking contexts, particularly as the loss ratio (to be defined later in this chapter) is one of the fundamental ratemaking metrics.

The terms associated with losses are paid loss, case reserve, reported or case incurred loss, IBNR/IBNER reserve, and ultimate loss. **Paid losses**, as the name suggests, are those amounts that have been paid to claimants. When a claim is reported and payment is expected to be made in the future, the insurer establishes a **case reserve**, which is an estimate of the amount of money required to ultimately settle that claim. The case reserve excludes any payments already made. The amount of the case reserve is monitored and adjusted as payments are made and additional information is obtained about the damages. **Reported loss** or case incurred loss is the sum of the paid losses and the current case reserve for that claim:

$$\text{Reported Losses} = \text{Paid Losses} + \text{Case Reserve}.$$

Ultimate loss is the amount of money required to close and settle all claims for a defined group of policies. The aggregate sum of reported losses across all known claims may not equal the ultimate loss for many years. Reported losses and ultimate losses are different for two reasons. First, at any point in time, there may be unreported claims. The amount estimated to ultimately settle these unreported claims is referred to as an **incurred but not reported (IBNR) reserve**. Second, the accuracy of case reserves on reported claims is dependent on the information known at the time the reserve is set; consequently, the reported losses on existing claims may change over time. The **incurred but not enough reported (IBNER) reserve** (IBNER is also known as development on known claims) is the difference between the aggregate reported losses at the time the losses are evaluated and the aggregate amount estimated to ultimately settle these reported claims. Therefore, estimated ultimate loss is the sum of the reported loss, IBNR reserve and IBNER reserve:

$$\text{Estimated Ultimate Losses} = \text{Reported Losses} + \text{IBNR Reserve} + \text{IBNER Reserve}.$$

Loss Adjustment Expense

In addition to the money paid to the claimant for compensation, the insurer generally incurs expenses in the process of settling claims; these expenses are called **loss adjustment expenses (LAE)**. Loss adjustment expenses can be separated into **allocated loss adjustment expenses (ALAE)** and **unallocated loss adjustment expenses (ULAE)**:[1]

$$\text{LAE} = \text{ALAE} + \text{ULAE}.$$

ALAE are claim-related expenses that are directly attributable to a specific claim; for example, fees associated with outside legal counsel hired to defend a claim can be directly assigned to a specific claim. ULAE are claim-related expenses that cannot be directly assigned to a specific claim. For example, salaries of claims department personnel are not readily assignable to a specific claim and are categorized as ULAE.

Chapter 6 reviews loss and LAE data in detail, and outlines the various adjustments to such data for ratemaking analyses.

Underwriting Expenses

In addition to loss adjustment expenses (i.e., claim-related expenses), companies incur other expenses in the acquisition and servicing of policies. These are generally referred to as underwriting expenses (or operational and administrative expenses). Companies usually classify these expenses into the following four categories:

- Commissions and brokerage
- Other acquisition
- General
- Taxes, licenses, and fees

Commissions and brokerage are amounts paid to insurance agents or brokers as compensation for generating business. Typically, these amounts are paid as a percentage of premium written. It is common for commissions to vary between new and renewal business and may be based on the quality of the business written or the volume of business written or both.

Other acquisition costs are expenses other than commissions and brokerage expenses paid to acquire business. This category, for example, includes costs associated with media advertisements and mailings to prospective insureds.

General expenses include the remaining expenses associated with the insurance operations and any other miscellaneous costs. For example, this category includes costs associated with the general upkeep of the home office.

[1] Depending on the purpose, LAE can be separated into numerous different components. For example, statutory financial reporting separates LAE into defense and cost containment (DCC) and adjusting and other (A&O) expenses.

Taxes, licenses, and fees include all taxes and miscellaneous fees paid by the insurer excluding federal income taxes. Premium taxes and licensing fees are examples of items included in this category.

Underwriting Profit

As mentioned earlier, the ultimate cost of an insurance policy is not known at the time of the sale. By writing insurance policies, the company is assuming the risk that premium may not be sufficient to pay claims and expenses. The company must support this risk by maintaining capital, and this entitles it to a reasonable expected return (profit) on that capital. The two main sources of profit for insurance companies are underwriting profit and investment income. Underwriting profit, or operating income, is the sum of the profits generated from the individual policies and is akin to the profit as defined in most other industries (i.e., income minus outgo). Investment income is the income generated by investing funds held by the insurance company.

Chapter 7 outlines the derivation of underwriting expense provisions and how to incorporate the underwriting expenses and underwriting profit in ratemaking analysis. The derivation of the underwriting profit provision in consideration of investment income and a target return on equity is beyond the scope of this text.

FUNDAMENTAL INSURANCE EQUATION

Earlier in the chapter, the basic economic relationship for the price of any product was given as follows:

$$\text{Price} = \text{Cost} + \text{Profit}.$$

This general economic formula can be tailored to the insurance industry using the basic insurance terminology outlined in the preceding section. Premium is the “price” of an insurance product. The “cost” of an insurance product is the sum of the losses, claim-related expenses, and other expenses incurred in the acquisition and servicing of policies. Underwriting profit is the difference between income and outgo from underwriting policies, and this is analogous to the “profit” earned in most other industries. Insurance companies also derive profit from investment income, but a detailed discussion of this topic is beyond the scope of this text.

Making those substitutions, the prior formula is transformed into the fundamental insurance equation:

$$\text{Premium} = \text{Losses} + \text{LAE} + \text{UW Expenses} + \text{UW Profit}.$$

The goal of ratemaking is to assure that the fundamental insurance equation is appropriately balanced. In other words, the rates should be set so that the premium is expected to cover all costs and achieve the target underwriting profit. This is covered in the second principle of the CAS “Statement of Principles Regarding Property and Casualty Insurance Ratemaking” (CAS Committee on Ratemaking Principles, p. 6), which states “A rate provides for all costs associated with the transfer of risk.” There are two key points to consider in regards to achieving the appropriate balance in the fundamental equation:

1. Ratemaking is prospective.
2. Balance should be attained at the aggregate and individual levels.

Ratemaking is Prospective

As stated earlier, insurance is a promise to provide compensation in the event a specific loss event occurs during a defined time period in the future. Therefore, unlike most non-insurance products, the costs associated with an insurance product are not known at the point of sale and as a result need to be estimated. The ratemaking process involves estimating the various components of the fundamental insurance equation to determine whether or not the estimated premium is likely to achieve the target profit during the period the rates will be in effect.

It is common ratemaking practice to use relevant historical experience to estimate the future expected costs that will be used in the fundamental insurance equation; this does not mean actuaries are setting premium to recoup past losses. The first principle in the CAS "Statement of Principles Regarding Property and Casualty Insurance Ratemaking" states that "A *rate* is an estimate of the expected value of future costs" (CAS Committee on Ratemaking Principles, p. 6). Historic costs are only used to the extent that they provide valuable information for estimating future expected costs. When using historic loss experience, it is important to recognize that adjustments will be necessary to convert this experience into that which will be expected in the future when the rates will be in effect. For example, if there are inflationary pressures that impact losses, the future losses will be higher than the losses incurred during the historical period. Failure to recognize the increase in losses can lead to an understatement of the premium needed to achieve the target profit.

There are many factors that can impact the different components of the fundamental insurance equation and that should be considered when using historical experience to assess the adequacy of the current rates. The following are some items that may necessitate a restatement of the historical experience:

- Rate changes
- Operational changes
- Inflationary pressures
- Changes in the mix of business written
- Law changes

The key to using historical information as a starting point for estimating future costs is to make adjustments as necessary to project the various components to the level expected during the period the rates will be in effect. There should be a reasonable expectation that the premium will cover the expected losses and expenses and provide the targeted profit for the entity assuming the risk. Later chapters will discuss various techniques to adjust past experience for these and other items.

Overall and Individual Balance

When considering the adequacy or redundancy of rates, it is important to ensure that the fundamental insurance equation is in balance at both an overall level as well as at an individual or segment level.

Equilibrium at the aggregate level ensures that the total premium for all policies written is sufficient to cover the total expected losses and expenses and to provide for the targeted profit. If the proposed rates are either too high or too low to achieve the targeted profit, the company can consider decreasing or increasing rates uniformly. Two methods for calculating the overall adequacy of current rates are discussed in detail in Chapter 8.

In addition to achieving the desired equilibrium at the aggregate level, it is important to consider the equation at the individual risk or segment level. Principle 3 of the CAS "Statement of Principles Regarding Property and Casualty Insurance Ratemaking" states "A rate provides for the costs associated with an individual risk transfer" (CAS Committee on Ratemaking Principles, p. 6). A policy that presents significantly higher risk of loss should have a higher premium than a policy that represents a significantly lower risk of loss. For example, in workers compensation insurance an employee working in a high-risk environment (e.g., a steel worker on high-rise buildings) is expected to have a higher propensity for insurance losses than one in a low-risk environment (e.g., a clerical office employee). Typically, insurance companies recognize this difference in risk and vary premium accordingly. Failure to recognize differences in risk will lead to rates that are not equitable. Chapters 9 through 11 discuss how insurance companies vary rates to recognize differences between insureds.

BASIC INSURANCE RATIOS

Insurers and other interested parties (such as insurance regulators, rating agencies, and investors) rely on a set of basic ratios to monitor and evaluate the appropriateness of an insurance company's rates. This section provides a brief introduction to these ratios, which are further discussed in later chapters.

Frequency

Frequency is a measure of the rate at which claims occur and is normally calculated as:

$$\text{Frequency} = \frac{\text{Number of Claims}}{\text{Number of Exposures}}.$$

For example, if the number of claims is 100,000 and the number of earned exposures is 2,000,000, then the frequency is 5% (= 100,000 / 2,000,000). Normally, the numerator is the number of reported claims and the denominator is the number of earned exposures. As other variations may be used depending on the specific needs of the company, it is important to clearly document the types of claims and exposures used.

Analysis of changes in claims frequency can identify general industry trends associated with the incidence of claims or the utilization of the insurance coverage. It can also help measure the effectiveness of specific underwriting actions.

Severity

Severity is a measure of the average cost of claims and is calculated as:

$$\text{Severity} = \frac{\text{Losses}}{\text{Number of Claims}}.$$

Thus, if the total loss dollars are $300,000,000 and the number of claims is 100,000, then the severity is $3,000 (= $300,000,000 / 100,000). Severity calculations can vary significantly. For example, paid severity is calculated using paid losses on closed claims divided by closed claims. Reported severity, on the other hand, is calculated using reported losses and reported claims. Additionally, ALAE may be included or excluded from the numerator. Consequently, it is important to clearly document the types of losses and claims used in calculating the ratio.

Analyzing changes in severity provides information about loss trends and highlights the impact of any changes in claims handling procedures.

Pure Premium (or Loss Cost)

Pure premium (also known as loss cost or burning cost) is a measure of the average loss per exposure and is calculated as:

$$\text{Pure Premium} = \frac{\text{Losses}}{\text{Number of Exposures}} = \text{Frequency} \times \text{Severity}.$$

The term pure premium is unique to insurance and most likely was derived to describe the portion of the risk's expected costs that is "purely" attributable to loss.

Continuing with the example above, if total loss dollars are $300,000,000 and the number of exposures is 2,000,000, then the pure premium is $150 (= $300,000,000 / 2,000,000 = 5.0% x $3,000). Typically, pure premium is calculated using reported losses (or ultimate losses) and earned exposures. The reported losses may or may not include ALAE and/or ULAE. As companies may choose to use other inputs depending on the specific needs, it is important to document the inputs chosen.

Changes in pure premium highlight industry trends in overall loss costs due to changes in both frequency and severity.

Average Premium

The previous ratios focused on the loss portion of the fundamental insurance equation. However, it is also very important to analyze the premium side. A typical ratio is average premium, which is calculated as follows:

$$\text{Average Premium} = \frac{\text{Premium}}{\text{Number of Exposures}}.$$

For example, if the total premium is $400,000,000 and the total exposures are 2,000,000, then the average premium is $200 (=$400,000,000 / 2,000,000). It is important that the premium and the exposures be on the same basis (e.g., written, earned, or in-force).

Changes in average premium, if adjusted for rate change activity, highlight changes in the mix of business written (e.g., shifts toward higher or lower risk characteristics reflected in rates).

Loss Ratio

Loss ratio is a measure of the portion of each premium dollar used to pay losses and is calculated as:

$$\text{Loss Ratio} = \frac{\text{Losses}}{\text{Premium}} = \frac{\text{Pure Premium}}{\text{Average Premium}}.$$

For example, if the total loss dollars are $300,000,000 and the total premium is $400,000,000, then the loss ratio is 75% (= $300,000,000 / $400,000,000). Typically, the ratio uses total reported losses and total earned premium; however, other variations are common. For example, companies may include LAE in the calculation of loss ratios (commonly referred to as loss and LAE ratios). Once again, it is important to clarify the inputs being used.

Historically, most companies monitor and analyze the loss and LAE ratio as a primary measure of the adequacy of the rates overall and for various key segments of the portfolio.

Loss Adjustment Expense Ratio

The loss adjustment expense (LAE) ratio compares the amount of claim-related expense to total losses and is calculated as follows:

$$\text{LAE Ratio} = \frac{\text{Loss Adjustment Expenses}}{\text{Losses}}.$$

The loss adjustment expenses include both allocated and unallocated loss adjustment expenses. Companies may differ as to whether paid or reported (incurred) figures are used. It is important to recognize that the LAE are being divided by total losses and not by premium, so the loss and LAE ratio is not the sum of the loss ratio and the LAE ratio, but rather is the loss ratio multiplied by the sum of one plus the LAE ratio.

Companies monitor this ratio over time to determine if costs associated with claim settlement procedures are stable or not. A company may compare its ratio to those of other companies as a benchmark for its claims settlement procedures.

Underwriting Expense Ratio

The underwriting (UW) expense ratio is a measure of the portion of each premium dollar used to pay for underwriting expenses, and it is calculated as follows:

$$\text{UW Expense Ratio} = \frac{\text{UW Expenses}}{\text{Premium}}.$$

Often the company will subdivide the major underwriting expense categories into expenses that are generally incurred at the onset of the policy (e.g., commissions, other acquisition, taxes, licenses, and fees) and expenses that are incurred throughout the policy (e.g., general expenses). For the purpose of calculating the underwriting expense ratio, the former expenses are measured as a ratio to written premium and the latter expenses are measured as a ratio to earned premium. This is done to better match the expense payments to the premium associated with the expense and to better estimate what percentage of future policy premium should be charged to pay for these costs. The individual expense category ratios are then added to calculate the overall underwriting expense ratio.

A company will monitor this ratio over time and compare actual changes in the ratio to expected changes based on general inflation. A company may even compare its ratio to other companies' ratios as a benchmark for policy acquisition and service expenditures.

Operating Expense Ratio

The operating expense ratio (OER) is a measure of the portion of each premium dollar used to pay for loss adjustment and underwriting expenses and is calculated as:

$$\text{OER} = \text{UW Expense Ratio} + \frac{\text{LAE}}{\text{Earned Premium}}.$$

The OER is used to monitor operational expenditures and is key to determining overall profitability.

Combined Ratio

The combined ratio is the combination of the loss and expense ratios, and historically has been calculated as:

$$\text{Combined Ratio} = \text{Loss Ratio} + \frac{\text{LAE}}{\text{Earned Premium}} + \frac{\text{Underwriting Expenses}}{\text{Written Premium}}.$$

In calculating the combined ratio, the loss ratio should not include LAE or it will be double counted.

As mentioned in the section on underwriting expense ratio, some companies may compare underwriting expenses incurred throughout the policy to earned premium rather than to written premium. In this case, the companies may choose to define combined ratio as:

$$\text{Combined Ratio} = \text{Loss Ratio} + \text{OER}.$$

The combined ratio is a primary measure of the profitability of the book of business.

Retention Ratio

Retention is a measure of the rate at which existing insureds renew their policies upon expiration. The retention ratio is defined as follows:

$$\text{Retention Ratio} = \frac{\text{Number of Policies Renewed}}{\text{Number of Potential Renewal Policies}}.$$

If 100,000 policies are invited to renew in a particular month and 85,000 of the insureds choose to renew, then the retention ratio is 85% (= 85,000 / 100,000). There are a significant number of variations in how retention ratios are defined. For example, some companies exclude policies that cancel due to death and policies that an underwriter non-renews, while others do not.

Retention ratios and changes in the retention ratios are monitored closely by product management and marketing departments. Retention ratios are used to gauge the competitiveness of rates and are very closely examined following rate changes or major changes in service. They are also a key parameter in projecting future premium volume.

Close Ratio

The close ratio (also known as hit ratio, quote-to-close ratio, or conversion rate) is a measure of the rate at which prospective insureds accept a new business quote. The close ratio is defined as follows:

$$\text{Close Ratio} = \frac{\text{Number of Accepted Quotes}}{\text{Number of Quotes}}.$$

For example, if the company provides 300,000 quotes in a particular month and generates 60,000 new policies from those quotes, then the close ratio is 20% (= 60,000 / 300,000). Like the retention ratio, there can be significant variation in the way this ratio is defined. For example, a prospective insured may receive multiple quotes and companies may count that as one quote or may consider each quote separately.

Close ratios and changes in the close ratios are monitored closely by product management and marketing departments. Closed ratios are used to determine the competitiveness of rates for new business.

SUMMARY

This chapter introduces insurance ratemaking, which is unique because the cost of the insurance product is not known at the time the product is sold. The goal of insurance ratemaking is to assure the fundamental insurance equation is balanced; in other words, the premium should cover all expected costs and should achieve the targeted underwriting profit during the period the rates will be in effect. Two key considerations of this goal are that ratemaking is performed on a prospective basis and should ensure that the fundamental insurance equation is balanced both on an overall level as well as at an individual or segment level. Finally, this chapter outlined basic insurance terms and ratios.

KEY CONCEPTS IN CHAPTER 1

1. Relationship between price, cost and profit

2. Rating manuals

3. Basic insurance terms
    a. Exposure
    b. Premium
    c. Claim
    d. Loss
    e. Loss adjustment expense
    f. Underwriting expense
    g. Underwriting profit

4. Goal of ratemaking
    a. Fundamental insurance equation
    b. Ratemaking is prospective
    c. Overall and individual balance

5. Basic insurance ratios
    a. Frequency
    b. Severity
    c. Pure premium
    d. Average premium
    e. Loss ratio
    f. Loss adjustment expense ratio
    g. Underwriting expense ratio
    h. Operating expense ratio
    i. Combined ratio
    j. Retention ratio
    k. Close ratio

CHAPTER 2: RATING MANUALS

As stated in Chapter 1, the rating manual is the insurer's documentation of how to appropriately classify each risk and calculate the applicable premium associated with that risk. The final output of the ratemaking process is the information necessary to modify an existing rating manual or create a new one. In today's highly computerized environment, most insurance premiums are calculated by an automated system, but a written rating manual is still a useful aid for anyone who needs to understand the process of calculating an insurance premium. This includes insurance agents/brokers as well as insurance regulators who may require the manual as part of the rate regulation process. This chapter addresses what rate manuals typically include and gives examples of the different components for various lines of business.

The price a consumer pays for an insurance policy is referred to as the premium. A consumer's premium is generally calculated based on a given rate per unit of exposure. This rate, however, can vary significantly for risks with different characteristics. For most lines of business, the following information is necessary to calculate the premium for a given risk:

- Rules
- Rate pages (i.e., base rates, rating tables, and fees)
- Rating algorithm
- Underwriting guidelines

Generally speaking, the first three items are found in a company's rating manual, and the underwriting guidelines are maintained in a separate proprietary underwriting manual.

The following sections provide more detail on each of the components and contain simple rating examples for several lines of business.

RULES

Rating manual rules typically contain qualitative information that is needed to understand and apply the quantitative rating algorithms contained later in the manual. Since it is intended to be an aid in calculating premium, the manual and the rules therein are not meant to replicate the detail of the legal insurance contract itself.

The rules often begin with definitions related to the risk being insured. For example, rules for a homeowners insurer may define what is considered a primary residence. The rules also provide a summary of policy forms offered to the insured (if more than one form is offered), summarize what is covered by each (e.g., types of liability or damage), and outline any circumstances for limitation or exclusion of coverage. The rules may also outline various premium determination considerations (e.g., minimum premium, down payments, refunds in the event of cancellation).

An important and often lengthy portion of the rules defines how to properly classify a risk before the rating algorithm can be applied. As will be discussed in later chapters, classification ratemaking groups risks with similar characteristics and varies the rate accordingly. These risk characteristics are represented by rating variables with categories pre-defined by the insurer. In some cases, the categories are clear and need not be explained (for example, the limit of liability selected). In other cases, further explanation for the classification is required; for example, a homeowners manual may need to clarify whether a recently renovated old home qualifies for the new home discount. A workers compensation manual may list how to classify risks into specific classification codes (salespersons/outside, bank employees, janitorial services, etc.). Without clear classification criteria, the rating algorithm will be ambiguous and could result in improper premium calculation.

Rating manual rules may also contain information about optional insurance coverage, often referred to as endorsements or riders. This includes a definition of the optional coverage, any restrictions on such coverage, and any applicable classification rules. The rules may contain the rating algorithm for the optional coverage as well.

In addition to these rules, a company may have a set of underwriting guidelines that specifies additional acceptability criteria (e.g., a company may choose not to write a risk with two or more convictions of driving under the influence). While the underwriting guidelines can be contained in the rules, it is more common to include them in a separate underwriting manual.

RATE PAGES

For most lines of insurance, the rate varies significantly based on the characteristics associated with the risk. The rate pages generally contain the numerical inputs (e.g., base rates, rating tables, and fees) needed to calculate the premium.

A base risk is a specific risk profile pre-defined by the insurer. The base risk often represents a set of risk characteristics that are most common, though it can also be chosen based on reasons more related to marketing objectives. For example, the base risk selected by an insurer for personal automobile collision coverage may be an adult, married male, with a $500 deductible, who lives in a very populated area, etc. Though the company may have more policies with a $250 deductible, its objective is to encourage new insureds to purchase a deductible of $500 or higher. If the base is set at the $500 deductible, the agent/broker will most likely use this deductible in the initial premium quote. If the insured requests a comparison quote with a $250 deductible it will result in a higher premium, which may serve as a psychological deterrent to the insured. Another example may be a multi-product discount for homeowners who have an auto policy with the same insurer. Even if the majority of homeowner policyholders qualify for the discount, the insurer may choose not to use that as the base risk and hence the discount is not reflected in the initial quote. By doing so, the company can offer and market a discount to those insureds with multiple products. If, on the other hand, the company set the base equal to those who qualify for the discount, then there will be an increase in premium for those who do not qualify for the discount. Although the premium charged is the same in either case, a discount has more positive appeal than an increase in premium.

The base rate is the rate that is applicable to the base risk. As such, it is not usually the average rate. If the insurance product contains multiple coverages that are priced separately as in personal automobile insurance, then there is typically a separate base risk, base rate, and rating tables applicable to each coverage.

By definition, the rate for all risk profiles other than the base profile varies from the base rate. The rate variation for different risk characteristics is achieved by modifying the base rate by a series of multipliers or addends or some unique mathematical expression as defined in the rating algorithm. The characteristics are referred to as rating variables, and the rate variations are contained in rating tables. Certain rating variables may be referred to as discounts/surcharges or credits/debits. The variations from the base rate are often referred to as relativities, factors, or multipliers (if applied to the rating algorithm multiplicatively) or addends (if applied to the base rate or some other figure in an additive or subtractive fashion).

Table 2.1 provides some examples of typical rating variables used for various insurance products. The number and nature of rating variables used varies significantly by line of business and from insurer to insurer.

2.1 Typical Rating Variables

Type of Insurance	Rating Variables
Personal Automobile	Driver Age and Gender, Model Year, Accident History
Homeowners	Amount of Insurance, Age of Home, Construction Type
Workers Compensation	Occupation Class Code
Commercial General Liability	Classification, Territory, Limit of Liability
Medical Malpractice	Specialty, Territory, Limit of Liability
Commercial Automobile	Driver Class, Territory, Limit of Liability

Prior to the use of the computers for quoting insurance rates, it was typical for companies to calculate the rate for several of the most common combinations of rating characteristics and produce a set of pre-printed rates for the producer. The math was simply done by the company to minimize the calculations required by the agent/broker. As rating algorithms have become more complex and computers have become more common and powerful, this practice has become less common. Rather than final rates, rate pages today contain all the building blocks necessary to calculate rates.

In addition to varying risk characteristics, the premium charged must consider expenses incurred in the acquisition and servicing of insurance policies. Some expenses vary by the amount of premium (e.g., commission is usually a percentage of the premium) and some expenses are fixed regardless of the premium (e.g., the cost of issuing a policy). In some cases, a company will include an explicit expense fee in the rating algorithm to account for the fixed expenses and then incorporate a provision within the base rate to account for the variable expenses. In other cases, a company may incorporate all expenses via a provision within the base rates. When there is no explicit fee, the company may have a minimum premium that assures the premium charged is adequate to cover the expenses and perhaps some amount for minimal expected losses.

RATING ALGORITHMS

The rating algorithm describes in detail how to combine the various components in the rules and rate pages to calculate the overall premium charged for any risk that is not specifically pre-printed in a rate table. The algorithm is very specific and includes explicit instructions, such as:

- the order in which rating variables should be considered

- how the effect of rating variables is applied in the calculation of premium (e.g., multiplicative, additive, or some unique mathematical expression)
- the existence of maximum and minimum premiums (or in some cases the maximum discount or surcharge that can be applied)
- specifics associated with any rounding that takes place.

If the insurance product contains multiple coverages, then separate rating algorithms by coverage may apply.

The nature and complexity of rating algorithms for insurance policies can vary significantly by insurer and by product. A few simplified examples are included later in this chapter for illustrative purposes.

UNDERWRITING GUIDELINES

Underwriting guidelines are a set of company-specific criteria that can affect decisions made prior to calculating a rate (e.g., whether or not to accept the risk) or can alter aspects of the premium calculation. In particular, underwriting guidelines may be used to specify:

- **Decisions to accept, decline, or refer risks.** The underwriting guidelines may specify that risks with a certain set of characteristics (e.g., a household with two or more losses in the last 12 months) may not be eligible for insurance or the application must be referred to a senior underwriter.
- **Company placement.** Some insurance groups utilize distinct companies within their corporate structure to sell similar products at different prices to risks with different underwriting characteristics. For example, an insurance group may designate one of its companies to provide personal automobile insurance to preferred or low-risk drivers and another company to provide personal automobile insurance to nonstandard or high-risk drivers. In this case, the underwriting guidelines will provide information necessary to place the insured in the most appropriate company within the group. The practice of establishing separate companies to achieve this purpose is usually due to either regulatory issues (cannot get approval for the full spectrum of desired rates within one company) or different distribution systems (one company may sell through agents and another may sell directly to the consumer).
- **Tier placement.** Companies may establish rating "tiers" in jurisdictions that permit companies to charge different rates within a single company to risks with different underwriting characteristics. The underwriting guidelines specify the rules necessary to properly assign the insured to the correct tier. The rating algorithm and rate pages specify how the tier placement affects the premium calculation.
- **Schedule rating credits/debits.** Commercial lines products often use schedule rating to vary premium from the manual rates. Schedule rating involves the application of credits and debits for the presence or absence of characteristics. In some cases, the schedule rating criteria is very specific and no judgment is required or permitted. Other times, the schedule includes subjective factors allowing the underwriter to use judgment in the selection of credits or debits applied.

Historically, underwriting criteria were subjective in nature (as opposed to the more objective rating variables) and required underwriters to personally assess the risk and make subjective judgments. There has been a trend over time (especially for personal lines products) to designate new explanatory variables as underwriting criteria, which can then be used for placement into rating tiers or separate companies. As such, the line between rating and underwriting characteristics has become blurred.

While they are covered in this section of this chapter, the underwriting guidelines may not be part of the rating manual and may not be publicly available, unless required by statute. When possible, insurance companies consider their underwriting guidelines to be proprietary and take steps to keep them confidential. The trend to designate new explanatory variables as underwriting criteria has given some companies a competitive advantage by reducing the transparency of the rating algorithm.

Table 2.2 provides some examples of typical underwriting characteristics that companies use for various insurance products. The list is not intended to be exhaustive. The number and nature of underwriting characteristics used varies significantly by line of business and from insurer to insurer.

2.2 Examples of Typical Underwriting Characteristics

Type of Insurance	Underwriting Characteristics
Personal Automobile	Insurance Credit Score, Homeownership, Prior Bodily Injury Limits
Homeowners	Insurance Credit Score, Prior Loss Information, Age of Home
Workers Compensation	Safety Programs, Number of Employees, Prior Loss Information
Commercial General Liability	Insurance Credit Score, Years in Business, Number of Employees
Medical Malpractice	Patient Complaint History, Years Since Residency, Number of Weekly Patients
Commercial Automobile	Driver Tenure, Average Driver Age, Earnings Stability

HOMEOWNERS RATING MANUAL EXAMPLE

The following is an example of a simple rating algorithm[2] for a homeowners policy with the Wicked Good Insurance Company (Wicked Good or WGIC). Homeowners insurance covers damage to the property, contents, and outstanding structures, as well as loss of use, liability and medical coverage, The perils covered and amount of insurance provided is detailed in the policy contract. WGIC writes one home per policy. WGIC's homeowners rating manual can be used to calculate the premium for a homeowners insurance policy. The following are excerpts from WGIC's homeowners rating manual.

Base Rates

The exposure base for homeowners insurance is a home insured for one year. Table 2.3 shows the base rate for WGIC. This is the all-peril base rate.[3]

2.3 Base Rate

Coverage	Base Rate
All Perils Combined	$500

[2] This algorithm contains many elements commonly used in the industry, but is not meant to represent all rating algorithms. Insurers may use more variables or different variables, and combine them in different ways than expressed here.

[3] The rating plan described has a single base rate that is used for all perils and the relativities all apply to that one base rate. Recently, homeowners companies have begun to implement rating plans that have separate base rates for each major peril covered and the individual rating variable relativities are applied to the applicable base rate (e.g., burglar alarm discount applies to the theft base rate only).

Rating and Underwriting Characteristics

Amount of Insurance

Amount of insurance (AOI) is one of the key rating variables for homeowners insurance. AOI represents the amount of coverage purchased to cover damage to the dwelling and is the maximum amount the insurer expects to pay to repair or replace the home. Table 2.4 shows the rate relativities to be applied to Wicked Good's base rate depending on the amount of insurance purchased. According to the table, the base rate corresponds to a home with an amount of insurance of $200,000, which consequently has an AOI rate relativity of 1.00.

2.4 Amount of Insurance (AOI) Rating Table

AOI (in thousands)	Rate Relativity
$ 80	0.56
$ 95	0.63
$110	0.69
$125	0.75
$140	0.81
$155	0.86
$170	0.91
$185	0.96
$200	1.00
$215	1.04
$230	1.08
$245	1.12
$260	1.16
$275	1.20
$290	1.24
$305	1.28
$320	1.32
$335	1.36
$350	1.39
$365	1.42
$380	1.45
$395	1.48
$410	1.51
$425	1.54
$440	1.57
$455	1.60
$470	1.63
$485	1.66
$500	1.69
Additional $15K	0.03

If a policyholder purchases $425,000 of insurance for his home, a rate relativity of 1.54 will be applied to the base rate. Straight-line interpolation is generally used for values not explicitly displayed in the table.

Territory

The location of the home is another major determinant of homeowners insurance risk and is, therefore, a key rating variable. Homeowners insurers typically group similar geographic units (e.g., zip codes) together to form rating territories. WGIC grouped zip codes into five distinct rating territories. The rate relativities for each territory are shown in Table 2.5.

2.5 Territorial Rating

Territory	Rate Relativity
1	0.80
2	0.90
3	1.00
4	1.10
5	1.15

Because Territory 3 is the base territory, the Territory 3 relativity is 1.00 and all other territories are expressed relative to Territory 3.

Protection Class and Construction Type

Wicked Good's homeowners rates also vary by fire protection class and type of construction. The protection class is a ranking based on the quality of fire protection and the availability of water in the district. Class 1 indicates the highest quality protection while class 10 refers to the lowest quality protection.

2.6 Protection Class / Construction Type Rating Table

Protection Class	Construction Type	
	Frame	Masonry
1-4	1.00	0.90
5	1.05	1.00
6	1.10	1.05
7	1.15	1.10
8	1.25	1.15
9	2.10	1.75
10	2.30	1.90

Within each protection class, there is a separate relativity based on construction type. The two construction types identified are frame and masonry. Frame construction, which relies on lumber and wood products, is more susceptible than masonry to some types of loss, such as fire or hail loss; therefore, the frame relativities are higher than the masonry relativities across every protection class. The base rate for this two-way variable is Protection Class 1-4 Frame (though Protection Class 5 Masonry coincidentally has a relativity of 1.00).

Underwriting Tier

WGIC uses numerous underwriting characteristics that are not explicitly shown in the rating manual. The underwriting characteristics are used to place insurance policies into one of four distinct underwriting tiers based on the overall riskiness of the exposure to loss. The following table shows the relativity for each of the four tiers:

2.7 Underwriting Tier Rating Table

Tier	Rate Relativity
A	0.80
B	0.95
C	1.00
D	1.45

Tier D, which is considered the most risky, has the highest rate relativity.

Deductible

The policyholder can choose the deductible, the amount of each covered loss the insured must pay. The rate relativities for each deductible are displayed in the following table.

2.8 Deductible Rating Table

Deductible	Rate Relativity
$250	1.00
$500	0.95
$1,000	0.85
$5,000	0.70

Miscellaneous Credits

Wicked Good offers discounts for new homes, insureds who are claims-free in the previous five years, and insureds with multiple policies (i.e., they have an auto or excess liability policy with WGIC in addition to a homeowners policy). The following table shows the discount applicable for each of these characteristics.

2.9 Miscellaneous Credits

Miscellaneous Credit	Credit Amount
New Home Discount	20%
5-Year Claims-Free Discount	10%
Multi-Policy Discount	7%

Frequently, companies with a significant number of discounts will have a maximum discount percentage that can be accumulated. For this example, Wicked Good does not limit the overall cumulative discount based on all miscellaneous credits.

Additional Optional Coverages

Homeowners policies place a limit on the amount of insurance by coverage (e.g., dwelling, contents, other structures, medical, and liability) though the policyholder can elect to purchase additional coverage. It is also common for the policy to limit the amount of coverage provided for certain types of losses (e.g., jewelry, cash, electronic equipment); these are referred to as inside limits. The limited coverage is considered sufficient for most policyholders. Those with a greater exposure to specific types of loss are encouraged to buy additional coverage. Also, policyholders may seek to extend the type of loss covered under the homeowners policy (e.g., to include coverage for the liability of operating a daycare in the home or to extend the perils covered for jewelry, watches, and furs losses). There are numerous other examples of how policyholders may choose to increase (or even decrease) their coverage.

In the following example, the basic homeowners policy includes a $100,000 limit for liability coverage and a $500 limit for medical coverage. This is referred to as a split limit,[4] and is often expressed as $100,000 / $500. In addition, a $2,500 inside limit applies to jewelry losses within the contents coverage. Each of these is a limit for losses occurring from a single event. If desired, the insured can purchase additional coverage. The following tables show the additional premium charged if the policyholder elects to purchase additional higher limits:

2.10 Increased Jewelry Coverage

Jewelry Coverage Rate	
Limit	**Additive**
$ 2,500	Included
$ 5,000	$35
$10,000	$60

2.11 Increased Liability/Medical Limits

Liability/Medical Rate	
Limit	**Additive**
$100,000/$500	Included
$300,000/$1,000	$25
$500,000/$2,500	$45

Expense Fee

WGIC has an explicit expense fee in the rating manual that is intended to cover fixed expenses incurred in the acquisition and servicing of insurance policies.

The expense fee is $50 per policy, as shown in Table 2.12.

2.12 Expense Fee

Policy Fee
$50

[4] Note that in other lines of business, split limits may refer to a per person (claimant) limit and a per occurrence limit, or may refer to a per occurrence and aggregate limit.

Homeowners Rating Algorithm for WGIC

The rating algorithm details how to combine all of the rate page information to calculate the final premium for a homeowners policy for WGIC:

Total Premium = All-Peril Base Rate

x AOI Relativity

x Territory Relativity

x Protection Class / Construction Type Relativity

x Underwriting Tier Relativity

x Deductible Credit

x [1.0 - New Home Discount – Claims-Free Discount]

x [1.0 - Multi-Policy Discount]

+ Increased Jewelry Coverage Rate

+ Increased Liability/Medical Coverage Rate

+ Policy Fee.

It is common for companies to designate a rounding procedure after each step. WGIC rounds to the penny after each step and to the whole dollar at the final step.

Homeowners Rate Calculation Example for WGIC

WGIC is preparing a renewal quote for a homeowner currently insured with Wicked Good. The policy has the following risk characteristics:

- Amount of insurance = $215,000
- The insured lives in Territory 4.
- The home is frame construction located in Fire Protection Class 7.
- Based on the insured's credit score, tenure with the company, and prior loss history, the policy has been placed in Underwriting Tier C.
- The insured opts for a $1,000 deductible.
- The home falls under the definition of a new home as defined in Wicked Good's rating rules.
- The insured is eligible for the five-year claims-free discount.
- There is no corresponding auto or excess liability policy written with WGIC.
- The policyholder opts to increase coverage for jewelry to $5,000 and to increase liability/medical coverage limits to $300,000/$1,000.

The appropriate figures from Tables 2.3 - 2.12 in WGIC's rating manual are shown in the following table:

2.13 Entries from Rating Manual

Entries from Rating Manual	
Base Rate	$500
AOI Relativity	1.04
Territory Relativity	1.10
Protection Class / Construction Type Relativity	1.15
Underwriting Tier Relativity	1.00
Deductible Credit	0.85
New Home Discount	20%
Claims-Free Discount	10%
Multi-Policy Discount	0%
Increased Jewelry Coverage Rate	$35
Increased Liability/Medical Coverage Rate	$25
Expense Fee	$50

The rating algorithm from the rating manual can be applied to calculate the final premium for the policy:

$501 = $500 x 1.04 x 1.10 x 1.15 x 1.00 x 0.85 x [1.0 - 0.20 - 0.10] x [1.0 - 0] + $35 + $25 + $50.

MEDICAL MALPRACTICE RATING MANUAL EXAMPLE

Rating algorithms for commercial lines policies can also vary significantly based on the insurer and the line of business. Medical malpractice insurance is a type of professional liability policy that provides coverage to healthcare professionals in the event of a malpractice claim.

The following is a simplified example of a rating algorithm for a medical malpractice policy issued by WGIC for its Nurses Professional Liability program. WGIC's rating manual can be used to calculate the premium. The following are excerpts from WGIC's medical malpractice rating manual.

Base Rates

The exposure base for medical malpractice insurance is a medical professional insured for one year. The following table in Wicked Good's rating manual shows the base rates for annual medical malpractice coverage for its nurses program. WGIC's base rates vary depending on whether the professional is employed or operates his or her own practice.

2.14 Base Rates

	Annual Rate Per Nurse
Employed	$2,500
Self-Employed	$3,000

As shown in Table 2.14, the base rate for a self-employed nurse is higher than the base rate for an employed nurse.

Rating and Underwriting Characteristics

Specialty Factor

The policy premium varies based on the medical specialty. A low-risk specialty requires a lower premium than a high-risk specialty due to the lower likelihood of incurring a loss and the decreased severity of potential losses. Wicked Good varies the malpractice premium based on the specialties shown in Table 2.15.

2.15 Specialty Rating Table

Specialty	Rate Relativity
Psychiatric	0.80
Family Practice	1.00
Pediatrics	1.10
Obstetrics	1.30
All Other Specialties	1.05

Nurses practicing in obstetrics have the highest rate relativity due to their higher exposure to loss.

Part-time Status

By rule, professionals who work 20 hours or less per week are considered part-time professionals. For all part-time professionals, Wicked Good has determined that the rate should be 50% of the base rate shown in Table 2.16.

2.16 Part-time Rating Table

	Rate Relativity
Full-time	1.00
Part-time	0.50

Territory

Wicked Good varies the rate based on the location of the medical professional's practice. Table 2.17 shows the rate relativities that apply to the base rate to calculate the rate for a nurse in a specific territory.

2.17 Territory Rating Table

Territory	Rate Relativity
1	0.80
2	1.00
3	1.25
4	1.50

Claims-free Discount

Individual insureds who have been a policyholder with WGIC for at least three consecutive years immediately preceding the effective date of the current policy may qualify for a claims-free discount. To qualify for the claims-free discount, the individual insured cannot have cumulative reported losses in excess of $5,000 over the prior three years. The amount of the claims-free discount is 15%.

Schedule Rating

Many commercial lines insurers incorporate a schedule rating plan into their rating algorithms to adjust the manual premium based on additional specific objective criteria or the underwriter's judgment. An underwriter will credit (i.e., reduce the rate) for characteristics that reduce the exposure to loss and debit (i.e., increase the rate) for characteristics that increase the exposure to loss.

WGIC's schedule rating plan includes the following credits and debits.

A. Continuing Education – A credit of up to 25% for attendance at approved continuing education courses and seminars. The total hours spent at courses and seminars must be at least 15 hours in the prior 12 months.
B. Procedure – A debit of up to 25% for nurses who have professional licenses and/or scope of practice in high-risk exposure areas such as invasive surgery or pediatric care.
C. Workplace Setting – A debit of up to 25% for nurses that work in high-risk workplace settings, such as surgical centers and nursing homes.

Wicked Good also applies a maximum aggregate schedule rating credit or debit of 25%.

Limit Factors

The insured applying for coverage can choose different limits of coverage. WGIC offers different per claim and annual aggregate limits for its Nurse's Professional Liability program. The per claim limit is the total amount the insurer will pay for all losses from a single claim covered during the policy period. The annual aggregate limit is the total amount the insurer will pay annually for all events covered in the policy period. The limit options are often expressed in the rating manual as split limits (e.g., $100K/$300K implies $100K per claim and $300K annual aggregate). The following are the relativities corresponding to each limit option:

2.18 Limit Rating Table

Limit Option	Rate Relativity
$100K/$300K	0.60
$500K/$1M	0.80
$1M/$3M	1.00
$2M/$4M	1.15

Since defense costs can be a significant expense in a medical malpractice claim, companies may choose to issue policies that specifically include or exclude loss adjustment expenses in consideration of the policy limit. If the allocated loss adjustment expenses are included in the limit, then the total liability losses and allocated loss adjustment expenses paid by the insurer will not exceed the limit. In this example, WGIC pays all such adjustment costs in addition to the limit shown.

Deductible

The insured can choose to have a deductible to reduce the professional liability premium. The deductible represents the amount of each covered loss the insured must pay. The following table shows the deductible options available and the associated credit.

2.19 Deductible Rating Table

Deductible (Per Claim)	Credit
None	0%
$1,000	5%
$5,000	8%

Claims-made Factor

WGIC writes claims-made medical malpractice policies as opposed to occurrence policies. The major difference between claims-made and occurrence coverage is that the coverage trigger is the date the claim is reported rather than the date the event occurs. A policyholder who buys a claims-made policy for the first time is only offered coverage for claims occurring after the start of the policy and reported during the year. When the claims-made policy is renewed, coverage is provided for claims occurring after the original inception date and reported during the policy period. The claims-made maturity factors (also known as step factors) adjust the premium to recognize these coverage differences. In addition, extended reporting coverage covers claims that occur during the coverage period but are reported after the policy terminates. This coverage is generally purchased before a claims-made policy is going to terminate. For example, a doctor who retires may purchase extended reporting coverage to cover claims reported after the medical malpractice policy terminates. The additional premium for this coverage is calculated by applying the extended reporting factors to the otherwise applicable mature policy premium according to the years of prior claims-made coverage. More detail on claims-made coverage is provided in Chapter 16.

WGIC's table of claims-made factors and extended reporting factors are as follows:

2.20A Claims-Made Maturity Factors

Maturity	Factor
1st Year	0.200
2nd Year	0.400
3rd Year	0.800
4th Year	0.900
5th Year	0.950
6th Year	0.975
Mature	1.000

2.20B Extended Reporting Factors

Years of Prior Claims-made Coverage	Factor
12 Month	0.940
24 Month	1.700
36 Month	2.000
48 Month	2.250
60 Month	2.400

Group Credit

Wicked Good offers a discount for medical practices that insure more than one nurse under one policy, such as a group practice. The size of the credit depends on the number of nurses that are insured under the policy. The credits are as follows:

2.21 Group Credit

Number of Nurses	Credit
1	0%
2 – 14	5%
15+	10%

The final premium including the group credit should be calculated for each nurse and aggregated for all professionals to determine the premium for the group policy.

Minimum Premium

The rating manual specifies that the minimum premium for each nurse, after the application of all discounts, is $100.

Medical Malpractice Rating Algorithm for WGIC

The rating algorithm specifies that the rating variables in the rating manual are to be applied multiplicatively, not additively, in consecutive order. Also according to the manual, premium is rounded to the nearest penny after each step and to the nearest dollar amount at the end to determine the final premium per professional. The rating algorithm is as follows:

Total Premium per Professional = Higher of

(Base Rate per Nurse

x Specialty Relativity

x Part-time Status Relativity

x Territory Relativity

x (1.0 - Claims-free Discount)

x (1.0 +/- Schedule Rating Debit/Credit)

x Limit Relativity

x (1.0 - Deductible Credit)

x Claims-made Factor

x (1.0 - Group Credit))

and

Minimum Premium specified in the rating manual ($100 for WGIC).

The total premium for a policy with multiple professionals is the sum of the premium for the individual professionals on the policy.

Medical Malpractice Rate Calculation Example for WGIC

A practice of five nurses recently applied for medical malpractice coverage with WGIC. Wicked Good's quoted premium is $6,500 for a single policy covering the five professionals, after the application of all adjustments. The practice has recently added a psychiatric nurse, and has requested a new quote from WGIC to cover all six professionals on a single policy. Assume the following characteristics:

- The new nurse is an employed professional who works 15 hours per week.
- He was previously covered by an occurrence policy and is applying for a claims-made policy with WGIC.
- He practices in Wicked Good's Territory 3.
- He attended five hours of approved continuing education courses in the prior 12 months.
- He holds a professional license in senior care, which is considered high risk. He also works in a senior care facility. The underwriter has chosen to apply debits of 25% for each of these criteria, but the maximum aggregate debit allowable is 25%.
- The policy has $1M/$3M of coverage with a $1,000 deductible per claim.

The following rating tables from Wicked Good's rating manual can be used to calculate the premium that should be charged for this policy:

2.22 Entries from Rating Manual

Entries from Rating Manual	
Employed Annual Rate	$2,500
Specialty Relativity	0.80
Part-time Status Relativity	0.50
Territory 3 Relativity	1.25
Schedule Rating (subject to 25% maximum)	0%+25%+25% (capped at 25%)
Limit Relativity for $1M/$3M	1.00
Credit for $1000 Deductible	5%
Claims-made Factor	0.20
Group Credit	5%
Minimum Premium	$100

As per the rating algorithm from the rating manual, the premium for the individual nurse is calculated as follows:

$282 = $2,500 x 0.80 x 0.50 x 1.25 x [1.00 + 0.25] x 1.00 x [1.00 - 0.05] x 0.20 x [1.00 - 0.05].

This amount is above the minimum premium per nurse of $100 so the minimum premium does not apply. The total premium for the six individuals combined is as follows:

$6,782 = $6,500 + $282.

U.S. WORKERS COMPENSATION RATING MANUAL EXAMPLE

Workers compensation insurance is required for most U.S. employers[5] to indemnify employees who are injured on the job. Because employee welfare is so important, workers compensation is a heavily regulated line of business in every U.S. state. As part of the regulation, insurers are required to submit statistical information on worker's compensation losses and premium in significant detail. The National Council on Compensation Insurance (NCCI) is a U.S. organization that collects workers compensation data from insurers and aggregates the data for ratemaking purposes. The NCCI is the licensed rating and statistical organization for most states, but several states have independent bureaus or operate as monopolistic plans. The NCCI provides workers compensation insurers with loss cost estimates, which is the portion of the rates that covers the expected future losses and loss adjustment expenses for a policy. Workers compensation insurers must calculate their own rates by adjusting the NCCI loss costs to account for their underwriting expenses and any perceived difference in loss potential.

The end result of the workers compensation ratemaking analysis is a rate manual, showing the manual premium for each risk. The premium actually collected by the insurer is referred to as net premium, and it incorporates the manual rates, premium discounts, individual risk rating modifications (e.g., schedule rating, experience rating), and expense constants.

WGIC writes workers compensation insurance for small companies with 50 employees or less. It relies heavily on NCCI for the overall loss costs as well as for many of the rating tables, but is able to determine the expense provision needed to profitably write the business.

The following is a simple premium calculation example for a U.S. workers compensation policy.

Class Rate

The purpose of the classification system is to group employers with similar operations that have a similar exposure to loss based on the job duties performed by the employees. There are over 400 different classes recognized by the NCCI for which they collect data. Table 2.23 shows the class rates applicable for a specific operation (in this case, retirement living centers) that Wicked Good writes. These class rates are based on the NCCI class rates, adjusted for WGIC's expenses and perceived differences in loss potential.

2.23 Class Rates

Class	Rate per $100 of Payroll
8810-Clerical	0.49
8825-Food Service Employees	2.77
8824-Health Care Employees	3.99
8826-All Other Employees	3.79

[5] Workers compensation eligibility requirements vary by state.

The process of calculating a premium begins with determining which classes best describe the activities of the company seeking insurance. Then, with data obtained for the prospective insured, Wicked Good estimates the amount of exposure ($100s of payroll) expected for each class during the policy period. The premium for the class is determined by applying the rate per $100 of payroll from Table 2.23 to the estimated payroll for each class. These results are aggregated across all classes for which the prospective insured has exposures, and the resulting premium is called the manual premium.

Rating and Underwriting Characteristics

Experience Rating

Under manual rating, all insureds are grouped according to their business operation or classification. The manual rates are averages reflecting the usual conditions found in each class. Although each class contains similar risks, each risk within a class is different to some extent. Experience rating is designed to reflect these differences in loss potential.

Experience rating generally only applies for larger policies, which inherently are believed to have more stable loss experience. In fact, NCCI designates minimum aggregate manual premium for a company to be eligible for experience rating. Additionally, regulators mandate that experience rating be used if the employer meets the industry eligibility requirements.

When experience rating is used, the insurer compares the policy's prior loss experience to the expected statewide average for the same classes. The manual premium will be adjusted upward if the actual losses for the company are higher than expected and downward if the actual losses are lower than expected. The adjustment is referred to as the experience modification. More detail on experience rating is contained in Chapter 15.

Since WGIC only insures small companies, experience rating is not applicable to its insureds.

Schedule Rating

As described earlier for medical malpractice, schedule rating specifies a range of credits and debits that an underwriter can apply to modify the manual premium. While some schedule rating schemes are very objective, WGIC has a set of potential credits and debits that require the underwriter to apply judgment in the underwriting process. The underwriter uses judgment based on professional experience and internal guidelines to select a value between the maximum and minimum for each attribute. The following table shows the range of schedule credits and debits that Wicked Good's underwriters can apply:

2.24 Schedule Rating

Range of Modification					
Premises	**Classification Peculiarities**	**Medical Facilities**	**Safety Devices**	**Employees — Selection, Training, Supervision**	**Management — Safety Organization**
+/-10%	+/-10%	+/-5%	-5% - 0%	+/-10%	+/-5%

The overall maximum credit or debit that an underwriter can apply to a single policy is 25%. The policy must have an annual manual premium of at least $1,000 to qualify for schedule rating.

Premium Credits

Wicked Good offers various additional premium credits to its insureds for other factors that may reduce the risk of a workers compensation claim or limit the cost of a claim once an injury has occurred.

2.25 Premium Credits

Factor	Credit
Pre-employment Drug Screening	5%
Employee Assistance Program	10%
Return-to-Work Program	5%

These credits are not subject to any overall maximum credit.

Expenses

Expense Constant

Insurers may add a fixed fee to all policies to cover expenses common to all workers compensation policies. This fee, often referred to as an expense constant, does not vary by policy size and covers expenses that are not included in the manual rate.

Wicked Good's expense constant is $150 per policy.

Premium Discount

The manual rate includes an allowance for administrative expenses that vary with the size of the policy. Not all expenses increase uniformly as the premium increases; for example, a company with $200,000 of payroll may not generate twice the administrative expenses for the insurer as a $100,000 payroll insured. To adjust for this expense savings, workers compensation insurers reduce the premium for large insureds through the use of premium discounts.

Since Wicked Good only writes policies for small companies, it does not offer premium discounts.

Minimum Premium

The workers compensation rating manual specifies that the minimum premium for any policy is $1,500.

Workers Compensation Rating Algorithm for WGIC

The components of the rating manual can be combined using a single rating algorithm to calculate the final premium for a given policy.

Total Premium = Higher of

$$[\sum_{i=1}^{N}(\text{Class}_i \text{ rate x \$Payroll for class}_i / 100) \text{ where } N = \text{number of classes}$$

x (1.0+ Schedule Rating Factor)

x (1.0- Pre-Employment Drug Screening Credit)

x (1.0- Employee Assistance Program Credit)

x (1.0- Return-to-Work Program Credit)

+ Expense Constant]

and

Minimum Premium specified in the rating manual ($1,500 in this example).

Also according to the manual, premium is rounded to the nearest penny after each step and to the nearest dollar amount at the end to determine the total premium. Note that experience rating factors and premium discounts do not appear in Wicked Good Company's rating algorithm because these rating variables do not apply to its book of business.

Workers Compensation Rate Calculation Example for WGIC

A retirement living center has requested a quote. The following are characteristics of the retirement living center:

2.26 Payroll by Class

Class	Payroll
8810 – Clerical	$35,000
8825 - Food Service Employees	$75,000
8824 - Health Care Employees	$100,000
8826 - All Other Employees & Salespersons, Drivers	$25,000

- The center has trained its entire staff in first aid, and first aid equipment is available throughout the building.
- The center has been inspected by Wicked Good, and the premises are clean and well-maintained.
- The center requires all employees to be drug-tested prior to employment.

The first step in determining the premium is to compute the aggregate manual premium. The following table shows the computation of the manual premium for each class:

2.27 Manual Premium by Class

Class	Payroll	Payroll/$100	Rate per $100 of Payroll	Class Manual Premium
8810 Clerical	$35,000	$350	0.49	$171.50
8825 - Food Service Employees	$75,000	$750	2.77	$2,077.50
8824 - Health Care Employees	$100,000	$1,000	3.99	$3,990.00
8826 - All Other Employees	$25,000	$250	3.79	$947.50
Total	$235,000			$7,186.50

The manual premium for each class is calculated as the payroll divided by $100 multiplied by the applicable rate per $100 of payroll. The total manual premium for the policy is the sum of the manual premium for each class:

$7,186.50 = $171.50 + $2,077.50 + $3,990.00 + $947.50.

The underwriter has determined that the following credits should apply based on the retirement living center's characteristics:

2.28 Schedule Rating Modifications

Modification					
Premises	**Classification Peculiarities**	**Medical Facilities**	**Safety Devices**	**Employees — Selection, Training, Supervision**	**Management —Safety Organization**
-10%	0%	0%	-2.5%	-5%	0%

The total credit (i.e., reduction to manual premium) for schedule rating is 10% + 2.5% + 5% = 17.5%. The credit takes into account the first aid equipment, staff training, and cleanliness of the premises. The credit is less than the maximum allowable credit of 25%; therefore, the entire 17.5% credit is applied to the manual premium. The schedule rating factor that should be applied to the manual premium is:

0.825 =1.000 - 0.175.

The following other factors apply to the policy:

2.29 Entries from Wicked Good's Rating Manual

Entries from Rating Manual	
Pre-employment Drug Screening Credit	5%
Employee Assistance Program Credit	0%
Return-to-Work Program Credit	0%
Expense Constant	$150

The Employee Assistance Program credit and Return-to-Work credit do not apply to the policy because the center does not have those programs. The following is the total premium for the policy:

$5,782 = $7,186.50 x 0.825 x (1.0 - 0.05) x (1.0 - 0) x (1.0 - 0) + $150.

Since $5,782 is greater than the minimum premium per policy of $1,500, the total premium for the policy is $5,782.

SUMMARY

The rating manual is an aid for anyone who needs to understand the process of calculating an insurance premium. For most lines of business, the manual includes the rules, rate pages, rating algorithm, and possibly the underwriting guidelines.

The rules contain items such as key definitions and summaries of what the contract covers, instructions on how to classify risks for premium rating, and information on optional coverages. Rules may also contain underwriting guidelines, or these may be provided separately.

The rate pages generally contain the numerical inputs needed to calculate the premium. These include base rates, rating tables, and fees.

The rating algorithm is the precise mathematical expression of how to calculate the premium using the inputs from the rate pages.

Underwriting guidelines document company-specific rules around risk selection, risk placement, and additional premium adjustments from underwriting characteristics. Underwriting guidelines are typically not part of the rating manual (and therefore not publicly available) unless required by statute.

KEY CONCEPTS IN CHAPTER 2

1. Basic components of a rate manual
    a. Rules
    b. Rate pages
    c. Rating algorithm
    d. Underwriting guidelines

2. Simple rating examples
    a. Homeowners
    b. Medical malpractice
    c. U.S. workers compensation

CHAPTER 3: RATEMAKING DATA

One of the most significant underpinnings of the ratemaking process is data. The quality of the final rates depends largely on the quality and quantity of data available.

Most ratemaking work involves analyzing the adequacy of rates for existing insurance products. In this case, companies generally use internal historical data or industry historical data to project future profitability. To facilitate a good review, it is imperative that the company collects and maintains pertinent and consistent historical data. When pricing a new insurance product, the actuary will need to search for internal information that may have some relationship to the new product or acquire relevant external data.

This chapter provides high-level specifications for ratemaking data, introduces data aggregation methods, and provides insights on external data. Often an actuary is required to perform ratemaking analysis with more limited data than is discussed in this chapter. In those cases, an actuary must understand the impact of not having particular information and should examine the sensitivity of the results of the analysis to the various assumptions. With this understanding and the data that is available, the actuary can determine data specifications in a manner that minimizes distortions in the results of the study.

INTERNAL DATA

Data requirements are a function of the type of ratemaking analyses being undertaken. For example, it is not essential to know the individual characteristics for each policy or risk to perform an analysis of the adequacy of the overall rates for a given product. On the other hand, a full multivariate classification analysis requires significant historical detail about each item being priced (e.g., an individual risk, policy, or class of policies).

Typically, ratemaking analyses are performed on existing insurance products and primarily involve the use of internal historical data to project the future profitability. (External data is sometimes used as a benchmark to provide context to the internal historical data in cases where internal data may be sparse or unstable.) There are generally two types of internal data involved in a ratemaking analysis. The first is risk information, such as exposures, premium, claim counts, losses, and explanatory characteristics about the policy or the claim. The second type of information is accounting information, such as underwriting expenses and ULAE, which are typically available only at an aggregate level.

Data retrieval mechanisms for ratemaking analysis vary considerably from company to company. Some actuaries have access to a data mart specifically designed for ratemaking analyses. Other actuaries must access general company databases containing detailed transactional information and manipulate the data to make it more appropriate for ratemaking analysis. There are a myriad of scenarios that fit between these two extremes.

The following sections outline one particular set of database specifications for risk information and accounting information. These specifications are not intended to be data mart recommendations or guidelines but rather an example of what an actuary may encounter when retrieving company data for ratemaking purposes. The actuary should review the nuances of the individual insurance product and desired ratemaking analysis to conclude whether existing data specifications are adequate. In addition, the actuary should review the data for appropriateness for its intended purpose and reasonableness and comprehensiveness of the data elements. More detailed information on the actuary's responsibility with respect to data quality is contained in "Actuarial Standard of Practice No. 23, Data Quality" (Actuarial Standards Board of the American Academy of Actuaries).

Risk Data

Ratemaking analysis ultimately requires information about policy exposure and premium linked with the corresponding claim and loss information. Company databases, however, typically record this information in two separate databases: a policy database and a claim database.

Policy Database

The policy database is defined according to records (i.e., individual policies or some further subdivision of the policy) and fields (i.e., explanatory information about the record). The way a record is defined for a particular product's policy database depends on the exposure measure and the way premium is typically calculated. The following are examples of policy database organization for different lines of business:

- In homeowners insurance, a record may be a home for an annual policy period.
- In U.S. workers compensation insurance, rating is based on the payroll of relevant industry classifications so separate records are often maintained at the classification level.[6]
- In personal auto insurance, separate records are typically created for each coverage—though this could also be handled via a coverage indicator field in the database. Separate records also may be created for each individual auto on a policy (if multiple autos are insured on one policy); moreover, separate records may be maintained for individual operators on each auto. In summary, an auto policy insuring two drivers on two cars for six coverages could involve 24 records (or four records if coverage is handled as a field).

In addition to the various subdivisions mentioned above, records are also subdivided according to any changes in the risk(s) during the policy period. If a policy is amended during the policy term, then separate records are created for the partial policy periods before and after the change. Examples will be provided later to better illustrate this requirement.

The following are fields typically present for each record on the policy database:

- **Policy identifier**
- **Risk identifier(s):** As mentioned earlier, products may only insure one risk per policy, and policy identifier is sufficient. For other products that insure multiple risks on a policy, unique risk identifiers are required. As in the example above, vehicle number and operator number may be necessary for personal auto databases.
- **Relevant dates:** Each individual record contains the original effective and termination dates for the policy or coverage within a policy. If separate records are maintained for individual risks and/or individual coverages on the policy, the start date of each risk/coverage is recorded. For example, if collision coverage for a new car is added to an existing auto policy, a record is added with the relevant start date noted. In addition, if separate records are maintained for midterm amendments (e.g., a change in the deductible), the date of the amendment is recorded.

[6]Some workers compensation carriers record policy information at the individual employee level, but this is not common.

- **Premium:** This is typically the written premium associated with each record. If the line of business has multiple coverages, this information is recorded by coverage (represented either as a separate record or via a coverage indicator field). For example, personal auto insurance databases track premium separately for bodily injury, property damage, comprehensive, collision, etc. Earned and in-force premium can be calculated from the information on the record.
- **Exposure:** This is typically the written exposure associated with each record. If the line of business has multiple coverages, this information is recorded by coverage.
- **Characteristics**: Characteristics include rating variables, underwriting variables, and any other available information regarding the risk represented by the record. Some characteristics describe the policy as a whole (e.g., the year the policy originated with the company) and as such are the same for every record associated with a particular policy and period of exposure. Other characteristics describe individual risks (e.g., make/model of automobile) and consequently vary between different records on the same policy.

As separate records are generated for midterm adjustments, the characteristics corresponding to each record are those that were in effect during the relevant period of exposure (e.g., if records are split to reflect a deductible change, the first record shows the initial deductible and the subsequent record(s) shows the new deductible).

Frequently, risk characteristic information is captured in multiple databases across the company and, as such, may be difficult to obtain and merge. For some rating characteristics, it is advantageous to capture a stable element from which the rating characteristic can be derived. For example, age of driver is a typical rating variable for personal automobile insurance; however, it is better to capture the date of birth of the driver on the data record because the driver's date of birth will not change from one policy period to the next but the driver's age will.

The following example homeowners policies can help clarify the construction of the policy database:

- Policy A is written on January 1, 2010, with an annual premium of $1,100. The home is located in Territory 1 and the insured has a $250 deductible. The policy remains unchanged for the full term of the policy.
- Policy B is written on April 1, 2010, with an annual premium of $600. The home is located in Territory 2 and the insured has a deductible of $250. The policy is canceled on December 31, 2010.
- Policy C is written on July 1, 2010, with an annual premium of $1,000. The home is located in Territory 3 and has a deductible of $500. On January 1, 2011, the insured decreases the deductible to $250. The full annual term premium after the deductible change is $1,200.

Policy A expired at its original expiration date and had no changes, thus the entire policy can be represented with one record.

Policy B was canceled before the policy expired. This is represented by two records. The first record for Policy B contains the information known at the inception of the policy (e.g., one exposure and $600 in written premium). The second record represents an adjustment for the cancelation such that when aggregated, the two records show a result net of cancellation. As the policy was canceled 75% of the way through the policy period, the second record should show -0.25 exposure and -$150 (=25% x -$600) of written premium.

Policy C expired at the original expiration date, but has a mid-term adjustment; this is represented by three records. The first record includes all the information at policy inception. The second record negates the portion of the original policy that is unearned at the time of the amendment (i.e., -0.50 exposure and -$500 premium and deductible equal to $500). The third record represents the information applicable to the portion of the policy written with the new deductible (i.e., +0.50 exposure and +$600 premium and deductible equal to $250).

Table 3.1 is an example policy database for the three policies described above.

3.1 Policy Database

Policy	Original Effective Date	Original Termination Date	Transaction Effective Date	Ded	Terr	Other Chars	Written Exposure	Written Premium
A	01/01/10	12/31/10	01/01/10	$250	1	…	1.00	$1,100
B	04/01/10	03/31/11	04/01/10	$250	2	…	1.00	$600
B	04/01/10	03/31/11	12/31/10	$250	2	…	-0.25	-$150
C	07/01/10	06/30/11	07/01/10	$500	3	…	1.00	$1,000
C	07/01/10	06/30/11	01/01/11	$500	3		-0.50	-$500
C	07/01/10	06/30/11	01/01/11	$250	3	…	0.50	$600

*For illustrative purposes this is ordered by policy rather than transaction effective date.

In a more sophisticated data mart, information for Policy B would be aggregated to one record that shows a "net" exposure of 0.75 and "net" written premium of $450. Similarly, information for Policy C would be aggregated to two records representing before and after the deductible change. The first record would reflect the period of time with the $500 deductible and would have a "net" exposure of 0.50 and "net" written premium of $500. The second record reflecting the period of time with the $250 deductible would be identical to the third record in the original example. The exposure is 0.50 and written premium is $600. This type of transaction aggregation is required for statistical ratemaking analysis such as generalized linear models (discussed in more detail in Chapter 10).

Claims Database

Most companies maintain a separate database to capture all available information about the claims on a specific policy. In a claims database, each record generally represents a transaction tied to a specific claim (e.g., a payment or a change in reserve). The fields contain dates or other explanatory information with respect to that claim. Similar to the policy database, claims involving multiple coverages or causes of loss may be represented as separate records or via indicator fields.

The following are the fields typically present for each record on the claims database:

- **Policy identifier**
- **Risk identifier(s):** If relevant, the claim database contains a way to identify the risk that had the claim. This will be necessary to match the claim to the corresponding record in the policy database.
- **Claim identifier:** The claim database contains a unique identifier for each specific claim. This same identifier is used if the claim has multiple claim transaction records.
- **Claimant identifier:** The claim database contains a unique identifier for each specific claimant on a particular claim.

- **Relevant loss dates:** The claim record includes fields for the date of loss, the date the company was notified of the loss (i.e., the report date), and the date of the transaction for the specific record (e.g., date of a loss payment, reserve change, or claim status change).
- **Claim status**: This field is used to track whether the claim is open (i.e., still an active claim) or closed (i.e., has been settled). For some insurance products it may be common for claims to be re-opened. If that is the case, it may be advantageous to add the re-opened and re-closed status descriptions.
- **Claim count:** This field identifies the number of claims by coverage associated with the loss occurrence. Alternatively, if each record or a collection of records defines a single claim by coverage, aggregating claim counts can be accomplished without this explicit field.
- **Paid loss:** This field captures the payments made for each claim record. If there are multiple coverages, perils or types of loss, the loss payments can be tracked in separate fields or separate records. Additionally, if the product is susceptible to catastrophic losses (e.g., hurricanes for property coverage), then catastrophic payments are tracked separately either through a separate record or an indicator included on the record.
- **Event identifier:** This field identifies any extraordinary event (e.g., catastrophe) involving this particular claim.
- **Case reserve:** This field includes the case reserve or the change in the case reserve at the time the transaction is recorded. For example, if a payment of $500 is made at a particular date, and this triggers a simultaneous change in the case reserve, a record is established for this transaction and the paid loss and case reserve fields are populated accordingly. As with paid losses, the case reserve is recorded in separate fields or records by coverage, peril or type of loss and by catastrophe or non-catastrophe claim, if applicable.
- **Allocated loss adjustment expense:** Expenses incurred handling claims are called loss adjustment expenses (LAE) and are commonly separated into allocated and unallocated loss adjustment expenses. Allocated loss adjustment expenses (ALAE) are expenses that can be assigned to a specific claim and are included on the claim database. If ALAE can be subdivided into finer categorization, additional fields may be used accordingly. Unallocated loss adjustment expenses (ULAE) cannot be assigned to a specific claim and are handled elsewhere. For many insurance products, companies do not set ALAE reserves and only payments are tracked on the database. If the company sets a case reserve for ALAE, it is maintained in the database. As with losses, this is captured separately by coverage or peril and by catastrophe or non-catastrophe, if applicable.
- **Salvage/subrogation:** Companies may be able to recoup some payments made to the insured. If a company replaces property, the company assumes ownership of the damaged property. The damaged property may then be reconditioned and sold to offset part of the payments made for the loss; these recoveries are called salvage. When a company pays for an insured's loss, the company receives the rights to subrogate (i.e., to recover any damages from a third party who was at fault or contributed fault to the loss event). Any salvage or subrogation that offsets the loss is tracked and linked to the original claim, if possible.
- **Claim characteristics:** Companies may collect characteristics associated with the claims (e.g., type of injury, physician information). If this information is available, it is included on the claim database to the extent the analyst may want to study the characteristic. However, it is important to note that while studying the impacts of these characteristics on average claim size may be interesting for certain purposes (e.g., loss reserve studies), only characteristics known for every prospective or existing policyholder at the time of policy quotation are usable in the rating algorithm.

The following example policies can help clarify these data requirements.

- Policy A: A covered loss occurs on January 10, 2010. The claim is reported to the insurance company on January 15, 2010, and an initial case reserve of $10,000 is established. An initial payment of $1,000 is made on March 1, 2010, with a corresponding $1,000 reduction in the case reserve. A final payment of $9,000 is made on May 1, 2010, and the claim is closed.
- Policy B: No claim activity.
- Policy C: A covered loss occurs on October 1, 2010, is reported on October 15, 2010, and a case reserve of $18,000 is established. The insurer makes a payment of $2,000 on December 15, 2010, and reduces the case reserve to $17,000. An additional payment of $7,000 is made on March 1, 2011, and the case reserve is reduced to $15,000. The claim is closed on March 1, 2012, when the insurer makes a final payment of $15,000 and receives a $1,000 salvage recovery by selling damaged property.
- Policy C: A second loss occurs on February 1, 2011. The claim is reported on February 15, 2011, and an initial reserve of $15,000 is set. On December 1, 2011, the company pays a law firm $1,000 for fees related to the handling of the claim. The claim is closed on that date with no loss payments made.

The claim associated with Policy A generates three separate records: one when the claim is reported and the initial reserve is set, one when the first payment is made, and one when the last payment is made. There are no records for Policy B as no claims were reported. Policy C had two separate claims. The first claim generates four records: one when the claim is reported and the initial reserve is set, and three for the three different dates that payments and reserve adjustments are made. The second claim generates a record on the date it is reported and the initial reserve is set and a subsequent record on the date the claim is closed.

Table 3.2 is an example claims database for the claim activity on the three policies described above.

3.2 Claim Database

Policy	Claim Number	Accident Date	Report Date	Transaction Date	Claim Status	Claim Chars	Loss Payment	Case Reserve	Paid ALAE	Salvage/ Subrogation
A	1	01/10/10	01/15/10	01/15/10	Open	…	$ -	$10,000	$ -	$ -
A	1	01/10/10	01/15/10	03/01/10	Open	…	$1,000	$9,000	$ -	$ -
A	1	01/10/10	01/15/10	05/01/10	Closed	…	$9,000	$ -	$ -	$ -
C	2	10/01/10	10/15/10	10/15/10	Open	…	$ -	$18,000	$ -	$ -
C	2	10/01/10	10/15/10	12/15/10	Open	…	$2,000	$17,000	$ -	$ -
C	2	10/01/10	10/15/10	03/01/11	Open	…	$7,000	$15,000	$ -	$ -
C	2	10/01/10	10/15/10	03/01/12	Closed	…	$15,000	$ -	$ -	$1,000
C	3	02/01/11	02/15/11	02/15/11	Open	…	$ -	$15,000	$ -	$ -
C	3	02/01/11	02/15/11	12/01/11	Closed	…	$ -	$ -	$1,000	$ -

*For illustrative purposes this is ordered by policy rather than transaction date.

Accounting Information

Some data required for ratemaking is not specific to any one policy. In the case of a company selling multiple products, some data may not even be specific to any one product. The salary of the CEO is a good example of a specific expense that cannot be allocated to line of business or individual policy. More generally, underwriting expenses and unallocated loss adjustment expenses fall into this category and should be tracked at the aggregate level.

Underwriting expenses are expenses incurred in the acquisition and servicing of the policies. These expenses include general expenses, other acquisition expenses, commissions and brokerage, and taxes, licenses, and fees. While it may be possible to assign some of these expenses —like commissions —to specific policies, most of these expenses cannot be assigned. For example, general expenses include some of the costs associated with the company's buildings, and other acquisition expenses include items like advertising costs.

Loss adjustment expenses (LAE) are expenses incurred in the process of settling claims.

Allocated loss adjustment expenses (ALAE) are directly attributable to a specific claim and are, therefore, captured on the claim extract.

Unallocated loss adjustment expenses (ULAE), on the other hand, cannot be assigned to a specific claim. ULAE include items like the cost of a claim center or salaries of employees responsible for maintaining claims records. Since ULAE cannot be assigned to a specific claim, these too are tracked at the aggregate level.

Generally speaking, companies track the underwriting and unallocated loss adjustment expenses paid by calendar year. Further subdivision to items such as line of business and state may also be approximated. These aggregate figures can be used to determine expense provisions that will be used in the ratemaking process.

DATA AGGREGATION

The aforementioned policy, claim, and accounting databases must be aggregated for use in the ratemaking analysis. By maintaining data at a detailed level, the data can be aggregated in a variety of ways to support the different types of analyses described within this text. This section is intended to provide some basics of aggregating data. More detailed descriptions will be provided in later chapters.

When aggregating data for ratemaking purposes, three general objectives apply:

- Accurately match losses and premium for the policy
- Use the most recent data available
- Minimize the cost of data collection and retrieval.

Four common methods of data aggregation are calendar year, accident year, policy year, and report year. Each method differs in how well it achieves the objectives outlined above. Note that the methods will be discussed in terms of annual accounting periods though other periods (e.g., monthly, quarterly) can be used, too. Also, with the exception of calendar year aggregation, the annual period does not need to be a calendar year (e.g., January 1 to December 31) but could be a fiscal year (e.g., July 1 to June 30) as well.

Calendar year aggregation considers all premium and loss transactions that occur during the twelve-month calendar year without regard to the date of policy issuance, the accident date, or the report date of the claim. Calendar year earned premium and earned exposure implies all premium and exposures earned during that twelve month period. Hence, at the end of the calendar year, all premium and exposures are fixed. Calendar year paid losses consider all loss paid during the calendar year regardless of occurrence date or report date. Reported losses for the calendar year are equal to paid losses plus the change in case reserves during that twelve-month calendar year. At the end of the calendar year, all reported losses are fixed.

The advantage of calendar year aggregation is that data is available quickly once the calendar year ends. This information is typically collected for other financial reporting so it represents no additional expense to aggregate the data this way for ratemaking purposes. The main disadvantage of calendar year aggregation is the mismatch in timing between premium and losses. Premium earned during the calendar year come from policies in force during the year (written either in the previous calendar year or the current calendar year). Losses, however, may include payments and reserve changes on claims from policies issued years ago. Calendar year aggregation for ratemaking analysis may be most appropriate for lines of business or individual coverages in which losses are reported and settled relatively quickly, such as homeowners.

Accident year aggregation of premium and exposures follow the same precept as calendar year premium and exposures—and in fact, the method is often referred to as calendar-accident year or fiscal-accident year. Accident year aggregation of losses considers losses for accidents that have occurred during a twelve-month period, regardless of when the policy was issued or the claim was reported. Accident year paid losses include loss payments only for those claims that occurred during the year. Similarly, reported losses for accident year consist of loss payments made plus case reserves only for those claims that occurred during the year. At the end of the accident year, reported losses can and often do change as additional claims are reported, claims are paid, or reserves are changed.

Accident year aggregation represents a better match of premium and losses than calendar year aggregation. Losses on accidents occurring during the year are compared to premium earned on policies during the same year. Since accident year is not closed (fixed) at the end of the year, however, future development on those known losses needs to be estimated. Selecting a valuation date several months after the end of the year allows the emergence of some development in the data and therefore may improve estimation of ultimate losses.

Policy year aggregation, which is sometimes referred to as underwriting year, considers all premium and loss transactions on policies that were written during a twelve-month period, regardless of when the claim occurred or when it was reported, reserved, or paid. All premium and exposures earned on policies written during the year are considered part of that policy year's earned premium and earned exposures. Premium and exposures are not fixed until after the expiration date of all policies written during the year. Policy year paid losses include payments made on those claims covered by policies written during the year. Similarly, reported losses for the policy year consist of payments made plus case reserves only for those claims covered by policies written during the year. At the end of the policy year, losses can and often do change as additional claims occur, claims are paid, or reserves are changed.

Policy year aggregation represents the best match between losses and premium. Losses on policies written during the year are compared with premium earned on those same policies. Given that policy year exposures are not fully earned until after the end of the year (e.g., policy year exposures for a product with an annual policy term are not fully earned until 24 months after the start of the policy year), data takes longer to develop than both calendar year and accident year.

Report year aggregation is the fourth method. This method is similar to calendar-accident year except the losses are aggregated according to when the claim was reported, as opposed to when the claim occurred. This method is typically used for commercial lines products using claims-made policies (e.g., medical malpractice), which is discussed in more detail in Chapter 16.

The individual chapters dedicated to exposure, premium, and loss go into considerably more detail about aggregating different statistics (e.g., written and earned premium; paid and reported losses) under each of these aggregation methods.

Overall versus Classification Analysis

If the purpose of the ratemaking analysis is to review the adequacy of the overall rate level, the data can be highly summarized. Generally speaking, the premium, losses, and exposures can be aggregated by year (i.e., calendar year, accident year, policy year, report year) for the product and location (e.g., state) being analyzed.

On the other hand, if a classification analysis is being performed, then the data must be at a more granular level. For a traditional univariate classification analysis, the data can be aggregated by year (typically accident year or policy year) for each level of the rating variable being studied. For example, if it is a territorial analysis, then the premium, losses, and exposures should be aggregated by year for each territory. In the case of a multivariate analysis (i.e., a simultaneous analysis of multiple variables), it is preferable to organize data at the individual policy or risk level. Alternatively, the data can be aggregated by year for each unique combination of rating variables being studied. If numerous rating variables are being considered, the aggregation (and compression) may be minimal and not worth undertaking.

Limited Data

As mentioned earlier, actuaries are sometimes required to perform ratemaking analysis when the preferred data described above is not available. In such cases, the actuary must work with the data that is available and use actuarial judgment to overcome the data deficiencies. For example, earned premium by territory is normally used for an analysis of auto territorial relativities. If the company does not have earned premium by territory, the actuary may use in-force premium by territory to estimate the earned premium by territory.

EXTERNAL DATA

When pricing a new line of business, it may be necessary to use external data. Even when pricing an existing line of business, it is often helpful to supplement internal data with external data. The most commonly used sources of external information include data calls or statistical plan data, other aggregated insurance industry data, competitors' rate filings, and third-party data unrelated to insurance. As with internal data, it is the actuary's responsibility to select the data with due consideration of reasonableness, appropriateness, comprehensiveness, and other factors from the Actuarial Standards of Practice No. 23, Data Quality (Actuarial Standards Board of the American Academy of Actuaries) before using it.

Statistical Plans

As discussed above, companies use data for internal business purposes (e.g., ratemaking analysis). Data is also required by regulators. In the U.S., property and casualty insurance is regulated at the state level, and regulators frequently require companies to file statistical data in a consistent format. Normally, state regulators do not need detailed data for their purposes and the required statistical plan is a summary-based plan.

One example of a statistical plan is The Texas Private Passenger Automobile Statistical Plan, as promulgated by the Texas Commissioner of Insurance. For many years, Texas used a benchmark rate system for setting personal automobile premium. The state set benchmark rates from which companies could deviate. The benchmark rates were determined based on an analysis of statistical data provided by insurance companies writing personal automobile insurance in Texas. Texas required statistical data that was aggregated by territory, deductible, and driver class. In addition to being used as the basis for setting the benchmark rates, the data was publicly available and was used by companies to supplement internal analyses.

To comply with various states' requirements for aggregated industry data as well as for the industry's needs for aggregated data, certain industry service organizations have been formed to collect and aggregate data from a group of participating companies writing the same insurance product. For example, the National Council for Compensation Insurance (NCCI) and Insurance Services Office, Inc (ISO) are two such organizations that meet the U.S. industry's need for aggregated data. In addition to collecting and summarizing data, these organizations analyze the aggregated data and make the results of the analysis available to the participating companies. Alternatively, the participating companies may be able to request the aggregated data to perform their own independent analysis.

Because this information is used for detailed actuarial analysis, these statistical plans tend to collect data at the transactional level; consequently, the organizations have the flexibility to perform in-depth analysis at both the overall and segment levels.

In addition to these statistical plans, state regulators may initiate ad hoc data calls to address a specific need. Normally, this information is publicly available and can be a good source of additional ratemaking information for companies. For example, several state regulators have requested closed claim information on medical malpractice claims, and medical malpractice insurers may request the data to supplement their own data.

Other Aggregated Industry Data

Many insurance companies voluntarily report data to various organizations so that it can be aggregated and used by the insurance industry and in some cases by regulators, public policy makers, or the general public. For example, a large percentage of U.S. personal lines companies report quarterly loss data for the "Fast Track Monitoring System." Fast Track reports are often used by insurance companies and U.S. state regulators to analyze loss trends.

Another example of an organization that collects, aggregates, and analyzes insurance data is the Highway Loss Data Institute (HLDI). HLDI, which is sponsored by several U.S. personal auto insurance companies, compiles insurance data reported by member companies and provides detailed information related to loss information by type of car to member companies and public policy makers. HLDI also provides highly summarized information that can be useful to insurers as well as the general public. One such example is information on which make and model cars have the highest incident of auto injury.

Examples of other organizations that collect, report, and analyze insurance industry data are the Insurance Research Council (IRC), the Institute for Business and Home Safety (IBHS), and the National Insurance Crime Bureau (NICB). A more comprehensive list of aggregated industry data providers is beyond the scope of this text.

Competitor Rate Filings/Manuals

Depending on the jurisdiction, competitor rate filings may be available to the public. For example, U.S. companies may be required to submit rate filings to the appropriate regulatory body when changing rates or rating structures for some insurance products. Rate filings normally include actuarial justification for requested rate changes and the manual pages needed to rate a policy.

In the simplest scenario, the filed rate change may involve a change to base rates only. Even in this case, the filing may still include helpful information related to overall indicated loss cost levels and trends in losses and expenses. If, however, the company is making changes to rating variable differentials (e.g., driver age relativities, territorial relativities, amount of insurance relativities), then the filing may also include information about the indicated relationships between the different levels for each rating variable undergoing a change.

Companies may also be required to include the manual pages necessary to rate policies. As discussed in Chapter 2, the manual contains the rules, rating structures, and rating algorithms in use by the company. This information can be analyzed to estimate the overall average premium level charged by the company and the premium differences due to different characteristics. Often, it can be very difficult to get a complete copy of a competitor's rate manual. First, companies do not file a complete manual with each change, but rather file only the pages that are changing; therefore, it may take several filings to piece together a complete manual. Additionally, companies often create underwriting tiers for which most jurisdictions do not require companies to file the underwriting rules used to assign risks to the tiers. Since it is common for the underwriting tier rules to have a significant impact on the final premium, the rating manual without the underwriting rules is incomplete information.

Even if complete information is available, a company must take great care when relying on information from a competitor's rate filing. Each company has different insureds, goals, expense levels, and operating procedures. If the differences are material, then the competitor information may not be relevant. For example, a personal automobile insurer specializing in writing preferred or super-preferred drivers typically has different rates and rating variables than a non-standard personal automobile insurer. In a more extreme case, commercial lines products often entail discretionary pricing and underwriting rules that would make accurate estimation of a competitor's final premium even more difficult.

Other Third-Party Data

Ratemaking analysis is often supplemented with third-party data that is not specific to insurance. The most commonly used types of third-party data are economic data and geo-demographic data, but other sources are relevant, too.

Insurers may not have enough internal data to accurately project trends in expenses, premium, or losses. If that is the case, companies may supplement internal data with sources like the Consumer Price Index (CPI). Companies may examine the CPI at the component level (e.g., medical cost and construction cost indices) to find trends that are relevant to the insurance product being priced.

Insurance companies may also study geo-demographic data (i.e., average characteristics of a particular area). In the U.S., census data is frequently used to supplement insurance data. For example, population density can be an important predictor of the frequency of accidents. Other examples of geo-demographic data that may be useful include the following: weather indices, theft indices, and average annual miles driven.

Another prime example of third-party data used by insurance companies is credit data. Starting in the 1990s, personal lines insurers began to evaluate the insurance loss experience of risks with different credit scores. Insurers determined that credit is an important predictor of risk and began to vary rates accordingly. More recently, commercial lines companies have analyzed similar data available for corporations. In addition to credit, there is a wealth of information available related to different insurance products. The following are a few such examples for different insurance products:

- Personal automobile insurance: vehicle characteristics, department of motor vehicle records
- Homeowners insurance: distance to fire station
- Earthquake insurance: type of soil
- Medical malpractice: characteristics of hospital in which doctor practices
- Commercial general liability: type of owner (proprietor, stock)
- Workers compensation: OSHA inspection data.

SUMMARY

Data is required for all ratemaking, and the quality of the ratemaking conclusions is heavily dependent on the quality of the data used. For existing insurance products, it is important that companies track policy and claim data at the individual policy, risk, or risk segment level. By doing so, companies have the flexibility to aggregate data in different ways (e.g., calendar year, accident year, policy year, report year) and determine the granularity of the data needed depending on the type of analysis being performed (e.g., overall rate level analysis or classification analysis).

Companies often consider external data, if available. More specifically, companies may examine data from statistical plans and data calls, other aggregated insurance data, competitor rate filings, and data from other third-party sources. These types of data can be useful in pricing new lines of business or in supplementing internal data.

KEY CONCEPTS IN CHAPTER 3

1. Internal data
    a. Policy database
    b. Claim database
    c. Accounting data

2. Data aggregation
    a. Calendar year
    b. Accident year
    c. Policy year
    d. Report year

3. External data
    a. Data calls and statistical plans
    b. Other insurance industry aggregated data
    c. Competitor information
    d. Other third-party data

CHAPTER 4: EXPOSURES

Insurance provides indemnification in the event of a claim due to a loss within the limitations of the policy. An exposure is the basic unit that measures a policy's exposure to loss. It is logical, therefore, that the exposure serves as the basis for the calculation of premium. Base rates, as discussed in Chapter 2, are typically expressed as a rate per exposure. The premium is calculated as the base rate multiplied by the number of exposures and adjusted by the effect of rating variables and sometimes other fees.

This chapter covers:

- Criteria that should be considered when selecting an exposure base
- Special treatment of exposure for large commercial risks
- Methods of aggregating exposures (calendar year and policy year) and defining exposures (written, earned, unearned, and in-force)
- Brief discussion on measuring trends in inflation-sensitive exposure bases.

CRITERIA FOR EXPOSURE BASES

A good exposure base should meet the following three criteria: it should be directly proportional to expected loss, it should be practical, and it should consider any preexisting exposure base established within the industry.

Proportional to Expected Loss

The exposure base chosen should be directly proportional to expected loss. In other words, all else being equal, the expected loss of a policy with two exposures should be twice the expected loss of a similar policy with one exposure. However, this does not mean that the exposure base is the only item by which losses may systematically vary. In general, expected loss will vary by a substantial number of factors and these other factors should be used as rating or underwriting variables to further reflect these risk level differences. The factor with the most direct relationship to the losses should be selected as the exposure base. This also makes the exposure base more easily understood by the insured.

Consider homeowners insurance as an example. Intuitively, the expected loss for one home insured for two years is two times the expected loss of the same home insured for one year. The expected loss for homes does vary by a significant number of other characteristics, including the amount of insurance purchased. While the expected loss for a $200,000 home is higher than that for a $100,000 home, it may not necessarily be two times higher. So based on the criterion that the exposure base should be the factor most directly proportional to the expected loss, number of house years is the preferred exposure base, and amount of insurance should be used as a rating variable.[7]

If an exposure base is proportional to the expected loss, then the exposure base should be responsive to any change in exposure to risk. Another example can more clearly demonstrate how the exposure base for some insurance products can be responsive to even small changes in exposure. Payroll is the

[7] In the U.K. and other countries, some homeowners insurers use amount of insurance or number of bedrooms as an exposure base and adjust the rating algorithm to account for the fact that these variables are not directly proportional to expected loss.

commonly used exposure base for workers compensation insurance. As the number of workers increases (decreases) or the average number of hours worked increases (decreases), both payroll and the risk of loss increase (decrease) too. Thus, the exposure base (i.e., payroll) moves in proportion to expected losses, and the premium will change with this exposure base change as well.

Practical

The exposure base should be practical. In other words, the selected base should be objective and relatively easy and inexpensive to obtain and verify. By meeting these criteria, the exposure base will be consistently measured.

A well-defined and objective exposure base also precludes policyholders and producers/underwriters from manipulating exposure information for their own benefit through intentional dishonest disclosure. For example, asking a personal auto policyholder to declare estimated annual miles provides more opportunity for dishonesty than the use of car-years. This circumstance is referred to as moral hazard. Advances in technology, however, may change the choice of exposure base for personal auto insurance. Onboard diagnostic devices can accurately track driving patterns and transmit this information to insurance companies. As this technology becomes more prevalently used, personal auto insurers may consider miles driven as an alternative exposure base. In fact, some commercial long haul trucking carriers have implemented miles driven as an exposure base.

For products liability, the exposure base that is intuitively the most proportional to expected loss is the number of products currently in use. While companies normally know how many products were sold during specific time periods, it is difficult for most companies to accurately track how many of their products are actually being used during the period covered by the insurance policy. Therefore, the number of products in use is not a practical exposure base. Consequently, a gross sales figure is used as the exposure base for products liability insurance as it is a reasonable and practical proxy for products in use. Of course, gross sales will be a better proxy for a consumable good that is only in use for a short period of time (e.g., a cup of coffee) than a durable good that will be used for many years (e.g., a lawnmower).

Historical Precedence

Over time, the industry may discover a more accurate or practical exposure base than the one currently in use (e.g., the example of miles driven discussed in the previous section). While the advantages may be clear, any change in an exposure base should be very carefully considered prior to implementation for several reasons. First, any change in exposure base can lead to large premium swings for individual insureds. Second, a change in exposure base will require a change in the rating algorithm, which depending on the unique circumstances, may require a significant effort to adjust the rating systems, manuals, etc. Third, ratemaking analysis is normally based on several years of data. A change in exposure base may necessitate significant data adjustments for future analyses.

Workers compensation has historically used payroll as an exposure base. In the 1980s, there was a lot of pressure to change the exposure base to hours worked for medical coverage in order to correct perceived inadequacies of the exposure base for union companies with higher pay scales. Although hours worked made intuitive sense, the exposure base was not changed at that time, and one of the major reasons cited was concerns regarding the transition. Instead, the rating variables and rating algorithm were adjusted to address the inequities. This debate over the choice of workers compensation exposure base continues to reemerge.

The following table shows the exposure bases currently used for different lines of business. Multi-peril package policies such as commercial general liability use different exposure bases for pricing different aspects of the package policy.

4.1 Typical Exposure Bases

Line of Business	Typical Exposure Bases
Personal Automobile	Earned Car Year
Homeowners	Earned House Year
Workers Compensation	Payroll
Commercial General Liability	Sales Revenue, Payroll , Square Footage, Number of Units
Commercial Business Property	Amount of Insurance Coverage
Physician's Professional Liability	Number of Physician Years
Professional Liability	Number of Professionals (e.g., Lawyers or Accountants)
Personal Articles Floater	Value of Item

EXPOSURES FOR LARGE COMMERCIAL RISKS

Large commercial risks present unique challenges for ratemaking and for the use of more conventional exposure bases. As a result, ratemaking for large commercial risks is often done via composite rating and loss-rated composite rating.

Composite rating is used for some large commercial risks when the amount of exposure is difficult to track throughout the policy period. For example, some commercial multi-peril policies use different exposure measures for each aspect of coverage (e.g., sales revenue for general liability, amount of insurance or property value for commercial business property). The policy premium is initially calculated using estimates for each exposure measure along with the relevant rating algorithms for each coverage. These individual exposure estimates, however, are expected to change throughout the course of the policy term. Rather than auditing each exposure measure, a proxy measure is used to gauge the overall change in exposure to loss. For example, if property value is chosen as the proxy exposure measure, a 20% increase in property value during the policy term would trigger a premium adjustment of 20% for the whole policy's premium.

In loss-rated composite rating, premium is calculated based on the individual risk's historical loss experience (i.e., without any use of standard rating algorithms). In that case, the implicit exposure base is the risk. This rating technique is discussed in more detail in Chapter 15.

AGGREGATION OF EXPOSURES

Methods of Aggregation for Annual Terms

As described in Chapter 3, four common methods of data aggregation are calendar year, accident year, policy year, and report year. In regards to aggregating exposures, there are only two methods applicable: calendar year (which is the same as calendar-accident year) and policy year.

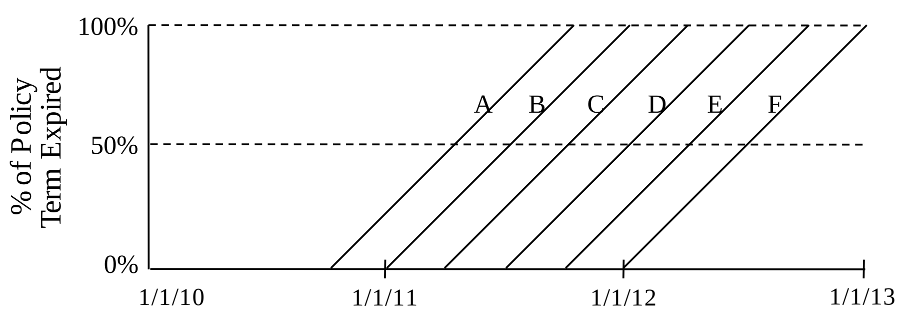
Example policies will be used to demonstrate these concepts. For simplicity, the example chosen (homeowners insurance) uses policies for which there is generally one exposure per policy. These example policies have annual terms; examples using semi-annual terms will be provided later in this chapter.

4.2 Policies

Policy	Effective Date	Expiration Date	Exposure
A	10/01/10	09/30/11	1.00
B	01/01/11	12/31/11	1.00
C	04/01/11	03/31/12	1.00
D	07/01/11	06/30/12	1.00
E	10/01/11	09/30/12	1.00
F	01/01/12	12/31/12	1.00

The aforementioned policies can be represented pictorially (see Figure 4.3). The x-axis represents time, and the y-axis represents the percentage of the policy term that has expired.[8] Each diagonal line represents a different policy. At the onset of the policy, 0% of the policy term has expired; thus, that point is located on the lower x-axis at the effective date. At the conclusion of the policy, 100% of the policy term has expired; thus, that point is located on the upper x-axis at the expiration date. The line connecting the effective and expiration points depicts the percentage of the policy term that has expired at each date.

4.3 Example Policies

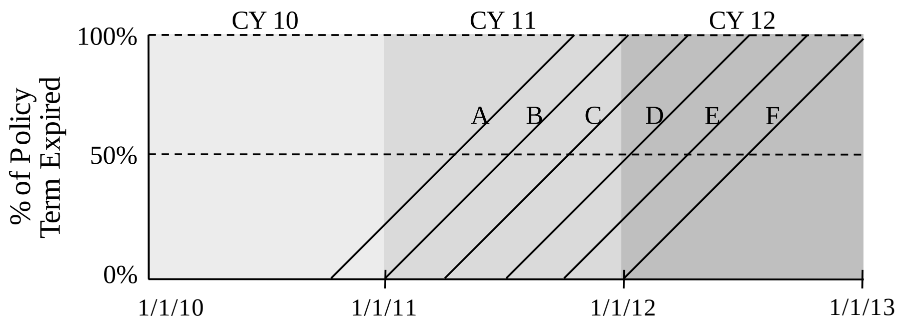


Calendar Year Aggregation and Accident Year Aggregation consider all exposures during the twelve-month calendar year without regard to the date of policy issuance; calendar and accident year exposures are generally the same[9] and the text will use the term calendar year exposure. At the end of the calendar year, all exposures are fixed. Since calendar year considers any transactions that occurred on or after the first day of the year, but on or before the last day of the year, calendar years are represented graphically as squares in the following picture.

[8] This assumes the policy is earned evenly throughout the policy period. Some products (e.g., warranties) do not earn evenly.

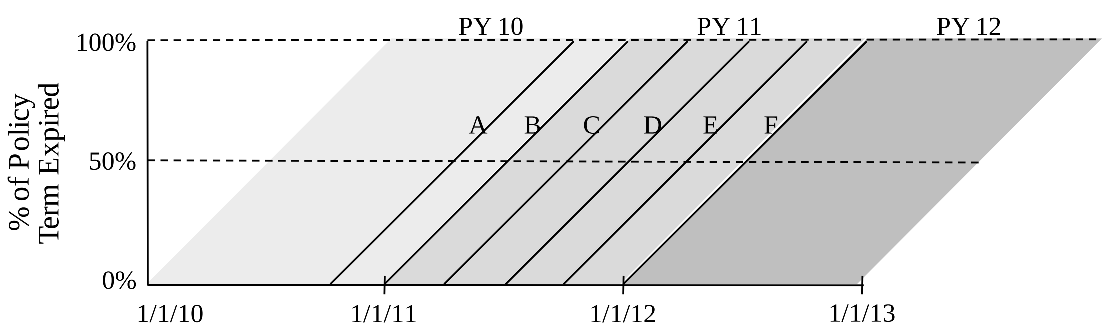
[9] There are some limited cases when the calendar and accident year exposures will not be equivalent. Policies that undergo audits will be discussed in the Premium Development section in the Premium Chapter.

4.4 Calendar Year Aggregation



Policy year aggregation, which is sometimes referred to as underwriting year, considers all exposures on policies with effective dates during the year. Thus, this is represented graphically using a parallelogram starting with a policy written on the first day of the policy year and ending with a policy written on the last day of the policy year:

4.5 Policy Year Aggregation

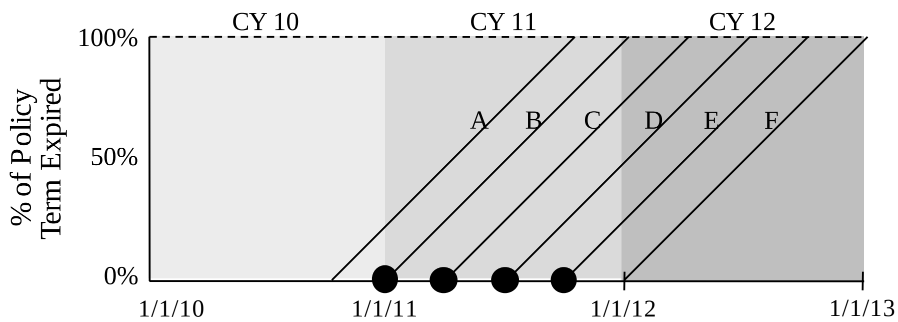


As demonstrated in the graph, the policy year takes significantly longer to close. For that reason, most ratemaking analysis focuses on calendar year exposures.

In addition to aggregating by calendar or policy year, exposures can be defined in four basic ways: written, earned, unearned, and in-force exposures.

Written exposures are the total exposures arising from policies issued (i.e., underwritten or, more informally, written) during a specified period of time, such as a calendar quarter or a calendar year. For example, the written exposure for Calendar Year 2011 is the sum of the exposures for all policies that had an effective date in 2011. As can be seen in Figure 4.6, Policies B, C, D and E all have effective dates (shown as large circles on the horizontal axis) in 2011, and their entire exposure contributes to Calendar Year 2011 written exposure. In contrast, Policies A and F have effective dates in years 2010 and 2012, respectively, and do not contribute to Calendar Year 2011 written exposure.

4.6 Calendar Year Written Exposures



The following table summarizes the distribution of written exposure to each calendar year:

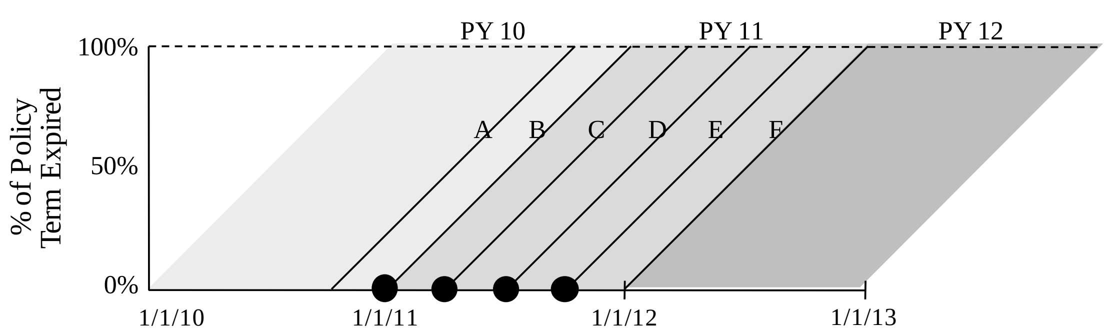
4.7 Calendar Year Written Exposures a/o 12/31/12

Policy	Effective Date	Expiration Date	Exposure	Written Exposures CY 2010	CY 2011	CY 2012
A	10/01/10	09/30/11	1.00	1.00	0.00	0.00
B	01/01/11	12/31/11	1.00	0.00	1.00	0.00
C	04/01/11	03/31/12	1.00	0.00	1.00	0.00
D	07/01/11	06/30/12	1.00	0.00	1.00	0.00
E	10/01/11	09/30/12	1.00	0.00	1.00	0.00
F	01/01/12	12/31/12	1.00	0.00	0.00	1.00
Total			6.00	1.00	4.00	1.00

Note each policy only contributes written exposure to a single calendar year in this example. If a policy cancels midterm, the policy will contribute written exposure to two different calendar years if the date of the cancellation is in a different calendar year than the original effective date. For example, if Policy D is cancelled on March 31, 2012 (i.e., after 75% of the policy has expired), then Policy D will contribute one written exposure to Calendar Year 2011 and -0.25 written exposure to Calendar Year 2012.

The following figure shows written exposure in the context of policy year aggregation.

4.8 Policy Year Written Exposure



The following table summarizes the distribution of written exposure to each policy year:

4.9 Policy Year Written Exposures a/o 12/31/12

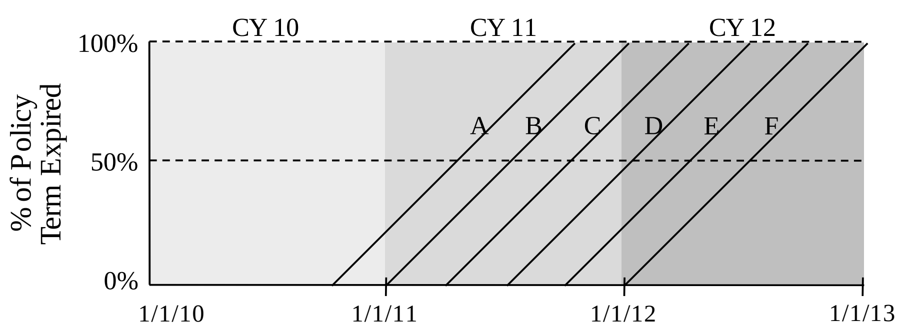
Policy	Effective Date	Expiration Date	Exposure	Written Exposures PY 2010	PY 2011	PY 2012
A	10/01/10	09/30/11	1.00	1.00	0.00	0.00
B	01/01/11	12/31/11	1.00	0.00	1.00	0.00
C	04/01/11	03/31/12	1.00	0.00	1.00	0.00
D	07/01/11	06/30/12	1.00	0.00	1.00	0.00
E	10/01/11	09/30/12	1.00	0.00	1.00	0.00
F	01/01/12	12/31/12	1.00	0.00	0.00	1.00
Total			6.00	1.00	4.00	1.00

Since policy year written exposure is aggregated by policy effective dates, the original written exposure and the written exposure due to the cancellation are all booked in the same policy year. As mentioned above, this contrasts with calendar year in which written exposure and cancellation exposure can apply to two different calendar years depending on when the cancellation occurs.

Earned exposures represent that portion of the written exposures for which coverage has already been provided as of a certain point in time. This example inherently assumes that the probability of a claim is evenly distributed throughout the year. For instance, if all policies were written on January 1 for a period of one year, the earned exposures as of May 31 would be 5/12 of the written exposures.

To better understand the difference between calendar and policy year earned exposure, first reconsider the calendar year picture:

4.10 Calendar Year Earned Exposure



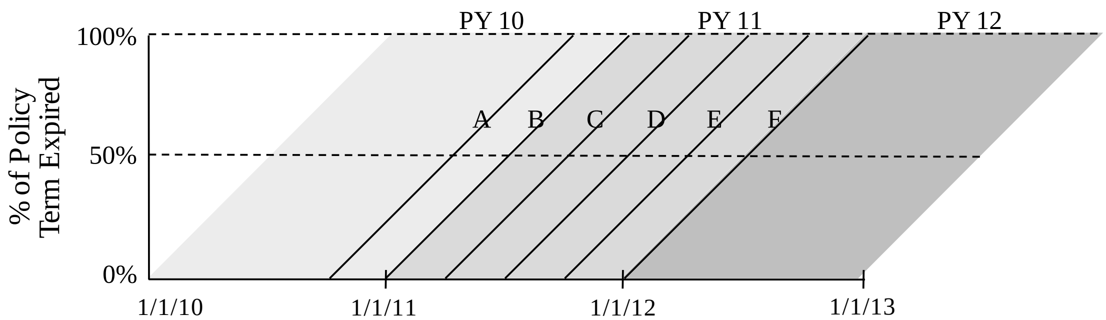
For Policy C in our example, 75% of the policy period is earned in 2011 and 25% of the policy period is earned in 2012; thus, Policy C contributes 0.75 (= 75% x 1.00) of earned exposure to Calendar Year 2011 and 0.25 earned exposure to Calendar Year 2012. The following chart summarizes the distribution of earned exposure to each calendar year:

4.11 Calendar Year Earned Exposures a/o 12/31/12

	Effective	Expiration		Earned Exposures		
Policy	**Date**	**Date**	**Exposure**	**CY 2010**	**CY 2011**	**CY 2012**
A	10/01/10	09/30/11	1.00	0.25	0.75	0.00
B	01/01/11	12/31/11	1.00	0.00	1.00	0.00
C	04/01/11	03/31/12	1.00	0.00	0.75	0.25
D	07/01/11	06/30/12	1.00	0.00	0.50	0.50
E	10/01/11	09/30/12	1.00	0.00	0.25	0.75
F	01/01/12	12/31/12	1.00	0.00	0.00	1.00
Total			6.00	0.25	3.25	2.50

In contrast, the following picture relates to policy year earned exposure.

4.12 Policy Year Earned Exposure



As can be seen in the picture, all earned exposure is assigned to the year the policy was written and increases in relation to time. By the time the policy year is complete (24 months after the beginning of the policy year for annual policies), the policy year earned and written exposures are equivalent. Unlike calendar year earned exposure, exposure for one policy cannot be earned in two different policy years. The following table shows the policy year earned exposures for policy years 2010 through 2012 as of December 31, 2012.

4.13 Policy Year Earned Exposures a/o 12/31/12

	Effective	Expiration		Earned Exposures		
Policy	**Date**	**Date**	**Exposure**	**PY 2010**	**PY 2011**	**PY 2012**
A	10/01/10	09/30/11	1.00	1.00	0.00	0.00
B	01/01/11	12/31/11	1.00	0.00	1.00	0.00
C	04/01/11	03/31/12	1.00	0.00	1.00	0.00
D	07/01/11	06/30/12	1.00	0.00	1.00	0.00
E	10/01/11	09/30/12	1.00	0.00	1.00	0.00
F	01/01/12	12/31/12	1.00	0.00	0.00	1.00
Total			6.00	1.00	4.00	1.00

The assumption of an even earning pattern does not hold true for lines such as warranty and those affected by seasonal fluctuations in writings (e.g., boat owners insurance). As such, actuaries analyzing these lines often specify other earning pattern assumptions based on historical experience.

Unearned exposures represent the portion of the written exposures for which coverage has not yet been provided as of that point in time. This applies to individual policies as well as groups of policies. For an individual policy at a certain point in time, the following formula depicts the relationship between written, earned, and unearned exposures:

Written Exposures = Earned Exposures + Unearned Exposures.

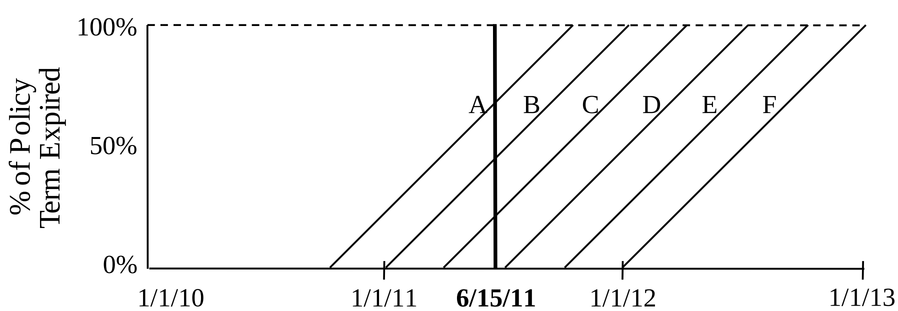
For groups of policies, the formula depends on the method of data aggregation. Policy year aggregation as of a certain point in time would follow the formula immediately above. Calendar year aggregation, however, would need to consider the unearned exposures at the beginning of the calendar year and at the end of the calendar year as follows:

CY Unearned Exposures = CY Written Exposures – CY Earned Exposures + Unearned Exposures as of the beginning of CY.

In-force exposures are the number of insured units that are exposed to having a claim at a given point in time. In other words, they represent the exposure to loss as a snapshot in time with no consideration for the duration of the exposure. The in-force exposure as of June 15, 2011, is the sum of insured units that have an inception date on or before June 15, 2011, and an expiration date after June 15, 2011. Not all insurance companies define “insured unit” the same way. Most companies define insured units to be the count of items exposed to loss at a given point in time. For example, if an automobile policy insures three cars, that one policy could contribute three in-force exposures at a given point in time. Alternatively, some companies may define insured unit in terms of the number of policies (the auto example above would have one in-force exposure under this definition) or the written exposures (in the auto example, there could be three in-force exposures if the term is annual, or 1.5 in-force exposures if the term is semi-annual).

A vertical line drawn at the valuation date will intersect the policies that are in-force on that date. As can be seen in Figure 4.14, Policies A, B, and C are all in effect on June 15, 2011, and each contributes to the in-force exposures as of that date.

4.14 In-Force Exposure



Assuming the "insured unit" refers to the number of houses exposed to loss, the following chart shows the in-force exposure for the example policies at three different valuation dates:

4.15 In-force Exposure by Date

Policy	Effective Date	Expiration Date	Number of Houses Insured	In-Force Exposure a/o 01/01/11	06/15/11	01/01/12
A	10/01/10	09/30/11	1.00	1.00	1.00	0.00
B	01/01/11	12/31/11	1.00	1.00	1.00	0.00
C	04/01/11	03/31/12	1.00	0.00	1.00	1.00
D	07/01/11	06/30/12	1.00	0.00	0.00	1.00
E	10/01/11	09/30/12	1.00	0.00	0.00	1.00
F	01/01/12	12/31/12	1.00	0.00	0.00	1.00
Total			6.00	2.00	3.00	4.00

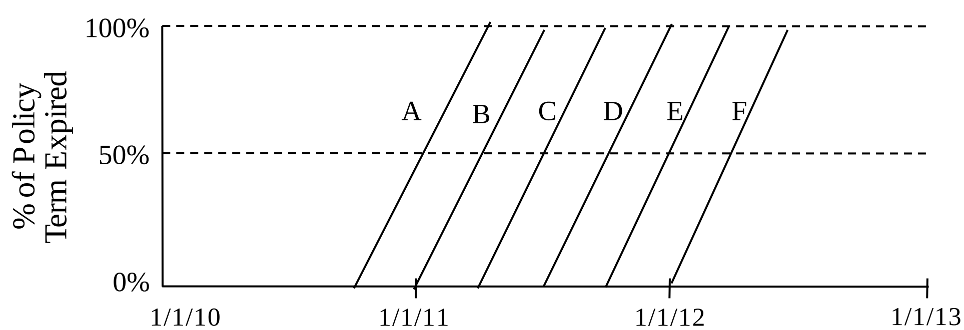
Policy Terms Other Than Annual

The preceding example illustrated the concepts of written, earned, unearned, and in-force exposures based on the assumption of annual policies. If the policy term is shorter or longer than a year, then the aggregation for each type of exposure will be calculated differently than outlined above. For example, if the policies are six-month policies, each policy would represent one-half of a written exposure. The picture and tables for calendar year and policy year aggregation of semi-annual policies are shown below.

4.16 Six-Month Policies

Policy	Effective Date	Expiration Date	Exposure
A	10/01/10	03/31/11	0.50
B	01/01/11	06/30/11	0.50
C	04/01/11	09/30/11	0.50
D	07/01/11	12/31/11	0.50
E	10/01/11	03/31/12	0.50
F	01/01/12	06/30/12	0.50

4.17 Example Policies



4.18 Calendar Year Written Exposures a/o 12/31/12

Policy	Effective Date	Expiration Date	Exposure	Written Exposures CY 2010	CY 2011	CY 2012
A	10/01/10	03/31/11	0.50	0.50	0.00	0.00
B	01/01/11	06/30/11	0.50	0.00	0.50	0.00
C	04/01/11	09/30/11	0.50	0.00	0.50	0.00
D	07/01/11	12/31/11	0.50	0.00	0.50	0.00
E	10/01/11	03/31/12	0.50	0.00	0.50	0.00
F	01/01/12	06/30/12	0.50	0.00	0.00	0.50
Total			3.00	0.50	2.00	0.50

4.19 Calendar Year Earned Exposures a/o 12/31/12

Policy	Effective Date	Expiration Date	Exposure	Earned Exposures CY 2010	CY 2011	CY 2012
A	10/01/10	03/31/11	0.50	0.25	0.25	0.00
B	01/01/11	06/30/11	0.50	0.00	0.50	0.00
C	04/01/11	09/30/11	0.50	0.00	0.50	0.00
D	07/01/11	12/31/11	0.50	0.00	0.50	0.00
E	10/01/11	03/31/12	0.50	0.00	0.25	0.25
F	01/01/12	06/30/12	0.50	0.00	0.00	0.50
Total			3.00	0.25	2.00	0.75

4.20 Policy Year Written Exposures a/o 12/31/12

Policy	Effective Date	Expiration Date	Exposure	Written Exposures PY 2010	PY 2011	PY 2012
A	10/01/10	03/31/11	0.50	0.50	0.00	0.00
B	01/01/11	06/30/11	0.50	0.00	0.50	0.00
C	04/01/11	09/30/11	0.50	0.00	0.50	0.00
D	07/01/11	12/31/11	0.50	0.00	0.50	0.00
E	10/01/11	03/31/12	0.50	0.00	0.50	0.00
F	01/01/12	06/30/12	0.50	0.00	0.00	0.50
Total			3.00	0.50	2.00	0.50

4.21 Policy Year Earned Exposures a/o 12/31/12

Policy	Effective Date	Expiration Date	Exposure	Earned Exposures PY 2010	PY 2011	PY 2012
A	10/01/10	03/31/11	0.50	0.50	0.00	0.00
B	01/01/11	06/30/11	0.50	0.00	0.50	0.00
C	04/01/11	09/30/11	0.50	0.00	0.50	0.00
D	07/01/11	12/31/11	0.50	0.00	0.50	0.00
E	10/01/11	03/31/12	0.50	0.00	0.50	0.00
F	01/01/12	06/30/12	0.50	0.00	0.00	0.50
Total			3.00	0.50	2.00	0.50

Assuming insured units are defined as number of homes insured at a point in time, each semi-annual policy can contribute to one in-force exposure.

4.22 In-force Exposure by Date

Policy	Effective Date	Expiration Date	Number of Houses Insured	In-Force Exposure a/o 01/01/11	06/15/11	01/01/12
A	10/01/10	03/31/11	1.00	1.00	0.00	0.00
B	01/01/11	06/30/11	1.00	1.00	1.00	0.00
C	04/01/11	09/30/11	1.00	0.00	1.00	0.00
D	07/01/11	12/31/11	1.00	0.00	0.00	0.00
E	10/01/11	03/31/12	1.00	0.00	0.00	1.00
F	01/01/12	06/30/12	1.00	0.00	0.00	1.00
Total			6.00	2.00	2.00	2.00

Calculation of Blocks of Exposures

The preceding section illustrated how to convert the total exposure of individual policies into written, in-force, earned, and unearned exposures. Advances in computing power have enabled such techniques to be applied to individual policies. On the other hand, some companies may have policy information summarized on a monthly or quarterly basis and will need to calculate the exposures for the block of policies using this summarized data. In such a case, it is customary for the practitioner to treat all policies as if they were written on the mid-point of the period. For example, when data is summarized on a monthly basis, all policies are assumed to be written on the 15th of the month. This practice is often referred to as the "15th of the month" rule or the "24ths" method. This will be a good approximation as long as policies are written uniformly during each time period. If this approach is applied to longer periods (e.g., quarters or years), the assumption of uniform writings is less likely to be reasonable.

To clarify the application of this rule, consider the following example in which a company begins writing annual policies in 2010 and writes 240 exposures each month.

The in-force exposures represent the total exposures from active policies at a given point in time. While it is reasonable to assume that some of the 240 exposures written in July were in-force as of the first day of the month, the "15th of the month" rule assumes that none of the exposures from the July policies contribute to the in-force exposures as of July 1, 2010. This is because the rule assumes all the July policies are written on July 15th. Table 4.23 shows the in-force exposures as of July 1, 2010; January 1, 2010; and July 1, 2011, respectively.

4.23 Aggregate In-force Calculation

Written Month	Exposure	Assumed Effective Date	In-force Exposures a/o 07/01/10	01/01/11	07/01/11
Jan-10	240	01/15/10	240	240	0
Feb-10	240	02/15/10	240	240	0
Mar-10	240	03/15/10	240	240	0
Apr-10	240	04/15/10	240	240	0
May-10	240	05/15/10	240	240	0
Jun-10	240	06/15/10	240	240	0
Jul-10	240	07/15/10	0	240	240
Aug-10	240	08/15/10	0	240	240
Sep-10	240	09/15/10	0	240	240
Oct-10	240	10/15/10	0	240	240
Nov-10	240	11/15/10	0	240	240
Dec-10	240	12/15/10	0	240	240
Total	2,880		1,440	2,880	1,440

As discussed earlier, the earned exposures represent the portion of the policy for which coverage has already been provided as of a certain point in time. Since the assumption is that all policies for a given month are written on the 15th of the month, the written exposures for annual policies will be earned over a 13-month calendar period: 1/24 of the exposure will be earned in the second half of the month in which it was written, 1/12 (or 2/24) of the exposure will be earned in each of the next 11 months (i.e., months 2 through 12), and the final 1/24 of the exposure will be earned in the first half of month 13. Table 4.24 shows the distribution of earned exposures to Calendar Years 2010 and 2011, respectively.

4.24 Aggregate Earned Exposure Calculation

(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Assumed	Earning Percentage		Earned Exposures	
Written Month	Exposures Written	Effective Date	2010	2011	2010	2011
Jan-10	240	01/15/10	23/24	1/24	230	10
Feb-10	240	02/15/10	21/24	3/24	210	30
Mar-10	240	03/15/10	19/24	5/24	190	50
Apr-10	240	04/15/10	17/24	7/24	170	70
May-10	240	05/15/10	15/24	9/24	150	90
Jun-10	240	06/15/10	13/24	11/24	130	110
Jul-10	240	07/15/10	11/24	13/24	110	130
Aug-10	240	08/15/10	9/24	15/24	90	150
Sep-10	240	09/15/10	7/24	17/24	70	170
Oct-10	240	10/15/10	5/24	19/24	50	190
Nov-10	240	11/15/10	3/24	21/24	30	210
Dec-10	240	12/15/10	1/24	23/24	10	230
Total	2,880				1,440	1,440

(4) = Portion of exposure earned in 2010.

(5) = Portion of exposure earned in 2011.

(6) = (2) x (4)

(7) = (2) x (5)

Though the above examples demonstrate the "15th of the month" rule on calendar year data, the same principles apply to policy year aggregation.

EXPOSURE TREND

As will be discussed in several subsequent chapters, the fundamental insurance equation requires that income (premium) equals outgo (loss and loss adjustment expenses and underwriting expenses), and target profit during the period in which the rates will be in effect. The chapters on premium and loss discuss trending procedures to adjust historical figures to the levels expected in the future.

For some lines of business, the exposure measure used is sensitive to time-related influences such as inflation. For example, payroll and sales revenue are highly influenced by inflationary pressures. In these lines of business, it may be prudent to measure the trend in historical exposures over time in order to project exposure levels in the future. These trends can be measured via internal insurance company data (e.g., workers compensation payroll) or via industry indices (e.g., average wage index). The way in which exposure trend impacts the calculation of the overall rate level indication depends on several factors such as whether the loss ratio or pure premium method is employed and how loss trends are calculated. The details will not be discussed in this chapter, but will be revisited in Chapters 5 and 6.

SUMMARY

Exposures are the basic unit used to measure risk. As such, the rate is defined as a price per unit of exposure. The exposure base used for a particular insurance product should be proportional to loss and practical to use. Furthermore, it is desirable that the exposure base used is consistent over time.

Exposures can be categorized as written, in-force, earned, or unearned and aggregated according to calendar year or policy year. Written exposure refers to the number of exposures associated with policies written during a specified period of time. In-force exposure refers to the number of exposures associated with all policies that are in effect on a given date. Earned exposure is the portion of the written exposure that corresponds to the portion of the policy period that has already expired. Unearned exposure is the portion of the written exposure that corresponds to the remaining or unexpired portion of the policy. The actual exposure used depends on the analysis being performed. When policy data is pre-summarized at the quarterly or monthly level, exposures are approximated by assuming each policy is written at the mid-point of the period (e.g., the "15^{th} of the month" rule for monthly data). Finally, when using inflation-sensitive exposure bases, it may be necessary to project future exposure levels, and this will be discussed further in subsequent chapters.

KEY CONCEPTS IN CHAPTER 4

1. Definition of an exposure

2. Criteria of a good exposure base
    a. Proportional to expected loss
    b. Practical
    c. Considers historical precedence

3. Exposure bases for large commercial risks

4. Exposure aggregation
    a. Calendar year v. policy year
    b. Written, earned, unearned, in-force

5. Calculation for blocks of exposure (“15th of the month” rule)

6. Exposure trend

CHAPTER 5: PREMIUM

The goal of ratemaking is to determine rates that will produce premium for a future policy period equivalent to the sum of the expected costs (i.e., losses and expenses) and the target underwriting profit. In other words, the goal is to balance the fundamental insurance equation:

$$\text{Premium} = \text{Losses} + \text{LAE} + \text{UW Expenses} + \text{UW Profit}.$$

This chapter covers the premium component of the fundamental insurance equation. Premium is the price the insured pays for the insurance product. The ratemaking process requires estimation of premium for a future policy period. This process generally begins with historical premium and applies a series of adjustments. The first adjustment is to bring the historical premium to the rate level currently in effect. Without this adjustment, any rate changes during or after the historical period will not be fully reflected in the historical premium and will distort the projection. A second adjustment is to develop premium to ultimate levels if the premium is still changing. A third adjustment is to project the historical premium to the premium level expected in the future. This accounts for changes in the mix of business that have occurred or are expected to occur after the historical experience period. These concepts are explained in detail in this chapter; in addition, Appendices A, C, and D provide realistic numeric examples from various lines of business of the premium adjustments made in ratemaking analysis.

As will be discussed in depth in the chapter on overall rate level indication, there are two general approaches to evaluate whether the rates underlying the company's premium adequately cover expected losses, expenses, and target underwriting profit: the pure premium approach and the loss ratio approach. Only the loss ratio approach requires the actuary to estimate the premium to be collected during the future time period; therefore, if the actuary plans to utilize the pure premium approach, the adjustments included within this chapter are not required.[10]

This chapter covers in detail:

- The different ways to define and aggregate premium
- Standard techniques used to adjust historical premium to current rate level
- Standard techniques used to develop historical premium to ultimate level
- Standard techniques used to measure and apply premium trend

PREMIUM AGGREGATION

Methods of Aggregation for Annual Terms

The methods for aggregating and defining premium are the same as discussed in the last chapter on exposures. For completeness, the following simple example is included to demonstrate these concepts:

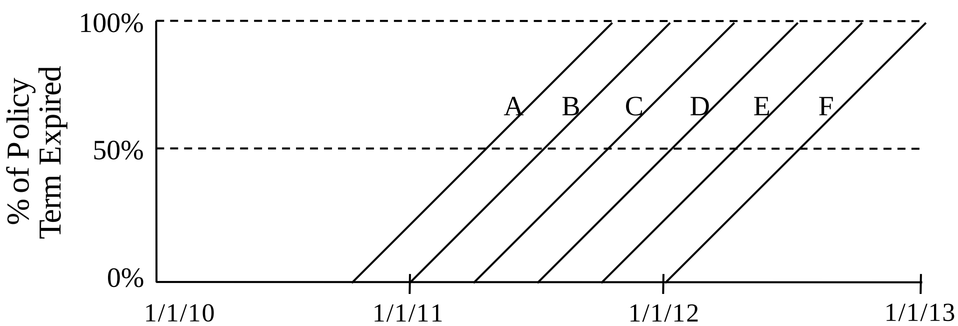
[10] However, the actuary may wish to calculate the expected premium underlying current rates to compare it to the needed premium output from the pure premium approach. The reasons for this should be clearer in the chapter discussing implementation issues.

5.1 Policies

Policy	Effective Date	Expiration Date	Premium
A	10/01/10	09/30/11	$200
B	01/01/11	12/31/11	$250
C	04/01/11	03/31/12	$300
D	07/01/11	06/30/12	$400
E	10/01/11	09/30/12	$350
F	01/01/12	12/31/12	$225

As with exposures, it is helpful to demonstrate the concepts using a graphical representation where time is reflected on the x-axis and the percentage of the policy that has expired is on the y-axis; Figure 5.2 shows the pictorial representation of each policy's duration from inception to expiration:

5.2 Example Policies

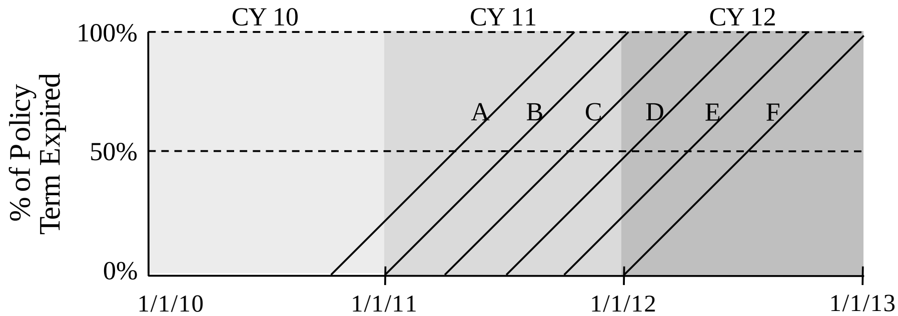


As described in Chapter 3, four common methods of data aggregation are calendar year, accident year, policy year, and report year. In regards to premium aggregation, there are only two methods applicable: calendar year and policy year. Report year is a loss concept only.

Calendar Year Aggregation and Accident Year Aggregation consider all premium transactions that occur during the twelve-month calendar year without regard to the date of policy issuance; calendar year and accident year premium are typically equivalent and the text will use the term calendar year premium.[11] At the end of the calendar year, the calendar year premium is fixed. Since calendar year considers any transactions that occurred on or after the first day of the year, but on or before the last day of the year, calendar years are represented graphically as squares, as shown in Figure 5.3.

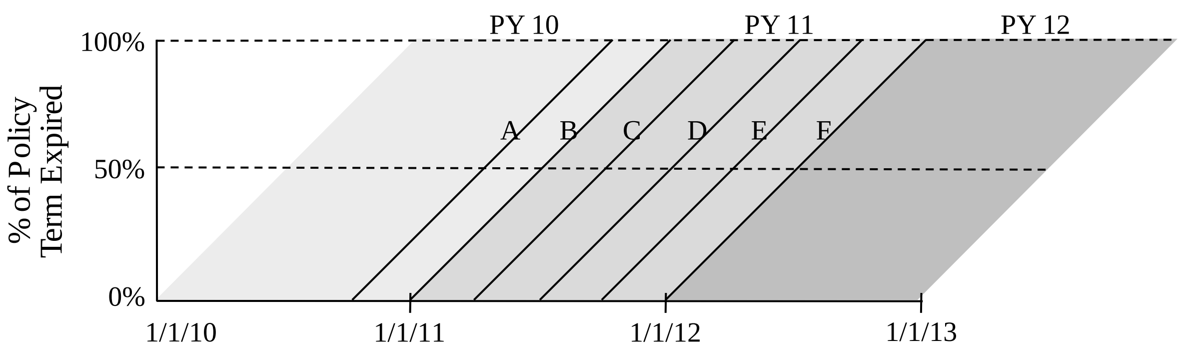
[11] There are some limited cases when the calendar and accident year premium will not be equivalent. This will be discussed in the Premium Development section later in this chapter.

5.3 Calendar Year Aggregation



Policy year aggregation, which is sometimes referred to as underwriting year, considers all premium transactions on policies with effective dates during the year. Thus, this is represented graphically using a parallelogram starting with a policy written on the first day of the policy year and ending with a policy written on the last day of the policy year:

5.4 Policy Year Aggregation

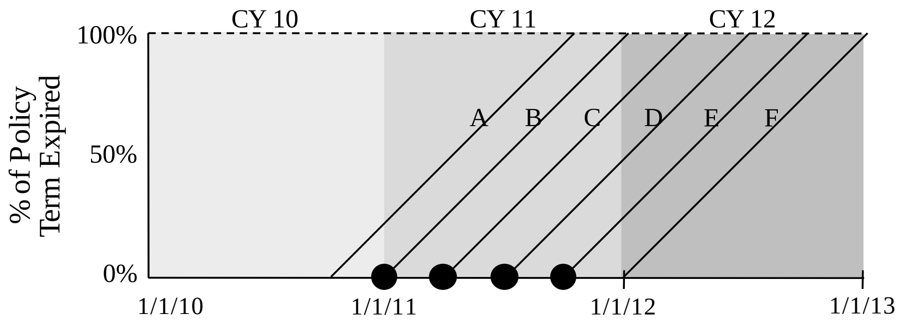


As can be seen clearly in the graph, the policy year assuming annual policies takes 24 months to complete. In contrast, the calendar year premium is fixed after 12 months. For that reason, most ratemaking analysis focuses on premium data aggregated by calendar year (and losses are generally aggregated on an accident year basis).

In addition to aggregating by calendar or policy year, premium can be defined in four basic ways: written premium, earned premium, unearned premium, and in-force premium.

Written premium is the total amount of premium for all policies written during the specified period. In other words, the key in determining written premium is the inception date of the policy (i.e., the base of each line in the figure). For example, the written premium for Calendar Year 2011 is the sum of the premium for all policies that had an effective date in 2011. As can be seen in Figure 5.5, Policies B, C, D, and E all have effective dates in 2011 (shown as large circles on the horizontal axis), and their entire premium contributes to Calendar Year 2011 written premium. In contrast, Policies A and F have effective dates in years 2010 and 2012, respectively, and do not contribute to Calendar Year 2011 written premium.

5.5 Calendar Year Written Premium



The following table summarizes the distribution of written premium to each calendar year:

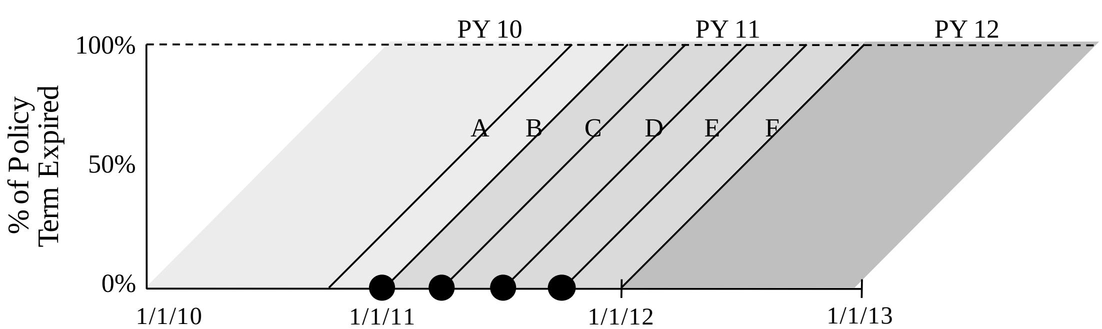
5.6 Calendar Year Written Premium a/o 12/31/12

Policy	Effective Date	Expiration Date	Premium	Written Premium CY 2010	Written Premium CY 2011	Written Premium CY 2012
A	10/01/10	09/30/11	$ 200.00	$ 200.00	$ -	$ -
B	01/01/11	12/31/11	$ 250.00	$ -	$ 250.00	$ -
C	04/01/11	03/31/12	$ 300.00	$ -	$ 300.00	$ -
D	07/01/11	06/30/12	$ 400.00	$ -	$ 400.00	$ -
E	10/01/11	09/30/12	$ 350.00	$ -	$ 350.00	$ -
F	01/01/12	12/31/12	$ 225.00	$ -	$ -	$ 225.00
Total			$1,725.00	$ 200.00	$1,300.00	$ 225.00

Note each policy only contributes written premium to a single calendar year in our example. If a policy has a mid-term adjustment that affects the premium, the policy will contribute written premium to two different calendar years if the date of the mid-term adjustment is in a different calendar year than the original effective date. For example, if Policy D is cancelled on March 31, 2012 (i.e., after 75% of the policy has expired), then Policy D will contribute $400 to Calendar Year 2011 written premium and -$100 (= 25% x -$400) to Calendar Year 2012 written premium.

The following figure shows written premium in the context of policy year aggregation.

5.7 Policy Year Written Premium



The following table summarizes the distribution of written premium to each policy year:

5.8 Policy Year Written Premium a/o 12/31/12

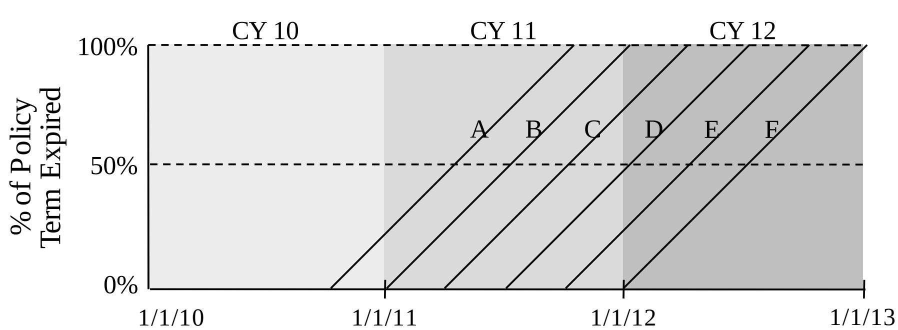
Policy	Effective Date	Expiration Date	Premium	Written Premium PY 2010	PY 2011	PY 2012
A	10/01/10	09/30/11	$ 200.00	$ 200.00	$ -	$ -
B	01/01/11	12/31/11	$ 250.00	$ -	$ 250.00	$ -
C	04/01/11	03/31/12	$ 300.00	$ -	$ 300.00	$ -
D	07/01/11	06/30/12	$ 400.00	$ -	$ 400.00	$ -
E	10/01/11	09/30/12	$ 350.00	$ -	$ 350.00	$ -
F	01/01/12	12/31/12	$ 225.00	$ -	$ -	$ 225.00
Total			$1,725.00	$ 200.00	$1,300.00	$ 225.00

Since policy year written premium is aggregated by policy effective dates, the original written premium and the written premium due to the cancellation are all booked in the same policy year. This contrasts with calendar year in which written premium and cancellation premium can apply to two different calendar years depending on when the cancellation occurs.

Earned premium is the amount of the premium the insurance company has already earned in relation to how much of the policy period has already expired. Stated another way, the earned premium is the premium for the coverage that has already been provided. This is important because earned premium represents the portion of the total premium that the insurance company is entitled to retain should the policy be canceled.[12]

To better understand the difference between calendar and policy year earned premium, first reconsider the calendar year picture:

5.9 Calendar Year Earned Premium



For Policy C in our example, 75% of the policy is earned in 2011 and 25% of the policy is earned in 2012; thus, Policy C contributes $225 (= 75% x $300) of earned premium to Calendar Year 2011 and $75 of earned premium to Calendar Year 2012. The following chart summarizes the distribution of earned premium to each calendar year:

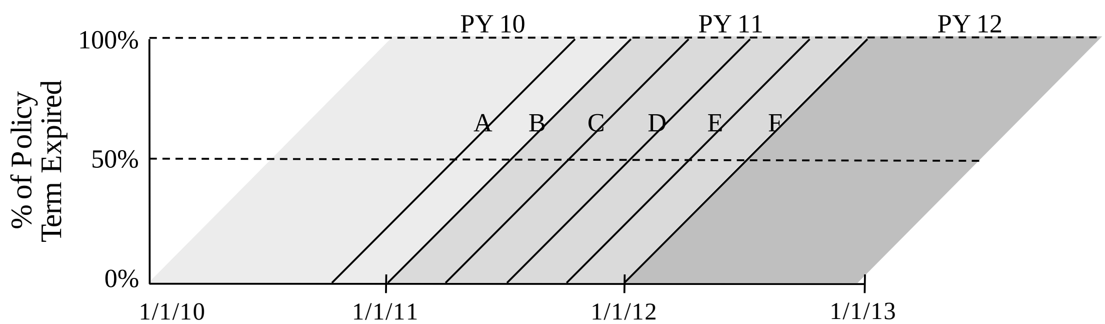
[12] Policies may contain a short rate table that entitles the company to retain an amount of premium that is greater than the pro rata amount of premium for the time expired on the coverage period. This is intended to reflect that some of the premium is designated to cover expenses incurred at the onset of the policy or to reflect that the insured risk may have much greater exposure to loss in part of the year (e.g., boat owners policies in many climates have the greatest exposure to loss in the summer months).

5.10 Calendar Year Earned Premium a/o 12/31/12

Policy	Effective Date	Expiration Date	Premium	Earned Premium CY 2010	CY 2011	CY 2012
A	10/01/10	09/30/11	$ 200.00	$ 50.00	$ 150.00	$ -
B	01/01/11	12/31/11	$ 250.00	$ -	$ 250.00	$ -
C	04/01/11	03/31/12	$ 300.00	$ -	$ 225.00	$ 75.00
D	07/01/11	06/30/12	$ 400.00	$ -	$ 200.00	$ 200.00
E	10/01/11	09/30/12	$ 350.00	$ -	$ 87.50	$ 262.50
F	01/01/12	12/31/12	$ 225.00	$ -	$ -	$ 225.00
Total			$1,725.00	$ 50.00	$ 912.50	$ 762.50

In contrast, the following picture relates to policy year earned premium.

5.11 Policy Year Earned Premium



As can be seen in the picture above and the table below, all earned premium is assigned to the year the policy was written and increases in relation to time until the policy year is complete. By the time the policy year is complete (24 months after inception), the policy year earned and written premium are equivalent. Unlike calendar year earned premium, premium for one policy cannot be earned in two different policy years. Also, the policy year premium is not fixed at the completion of the policy year. Premium for lines of business subject to premium audits will continue to develop after the end of the policy year period.

5.12 Policy Year Earned Premium a/o 12/31/12

Policy	Effective Date	Expiration Date	Premium	Earned Premium PY 2010	PY 2011	PY 2012
A	10/01/10	09/30/11	$ 200.00	$ 200.00	$ -	$ -
B	01/01/11	12/31/11	$ 250.00	$ -	$ 250.00	$ -
C	04/01/11	03/31/12	$ 300.00	$ -	$ 300.00	$ -
D	07/01/11	06/30/12	$ 400.00	$ -	$ 400.00	$ -
E	10/01/11	09/30/12	$ 350.00	$ -	$ 350.00	$ -
F	01/01/12	12/31/12	$ 225.00	$ -	$ -	$ 225.00
Total			$1,725.00	$ 200.00	$1,300.00	$ 225.00

Unearned premium is simply the portion of the premium that has not yet been earned at a given point in time. The importance of this figure is that it is the amount of the total premium that the company has not yet earned and the insured is entitled to get back in the event of a cancellation (subject to short rate table adjustments). At any time during the life of the policy, the written premium is simply the sum of the earned premium and unearned premium as shown in this formula:

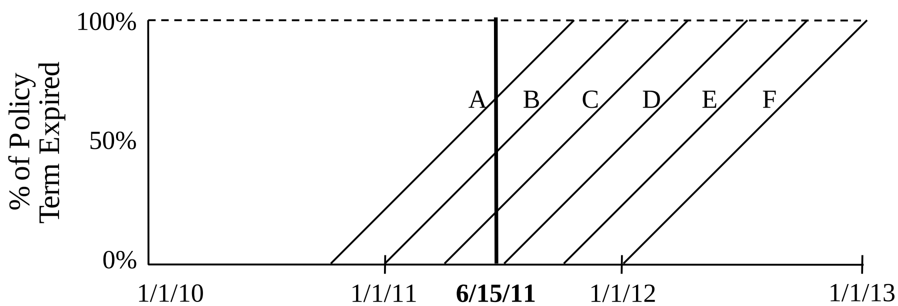
Written Premium = Earned Premium + Unearned Premium.

For aggregating premium across groups of policies, the formula depends on the method of data aggregation. Policy year aggregation would follow the formula immediately above. Calendar year aggregation, however, would need to consider the unearned premium at the beginning of the calendar year and at the end of the calendar year as follows:

CY Unearned Premium = CY Written Premium – CY Earned Premium + Unearned Premium as of the beginning of the CY.

In-force premium is the total amount of full-term premium for all policies in effect at a given date. More specifically, the in-force premium as of June 15, 2011, is the sum of full-term premium for all policies that have an inception date on or before June 15, 2011, and an expiration date on or after June 15, 2011. A vertical line drawn at the valuation date will intersect the policies that are in-force on that date. As can be seen in Figure 5.13, Policies A, B, and C are all in effect on June 15, 2011, and each contributes to the total in-force premium as of that date.

5.13 In-Force Premium



The following chart shows the in-force premium for a few example dates:

5.14 In-force Premium by Date

Policy	Effective Date	Expiration Date	Premium	In-Force Premium as of: As of 1/1/11	As of 6/15/11	As of 1/1/12
A	10/01/10	09/30/11	$ 200.00	$ 200.00	$ 200.00	$ -
B	01/01/11	12/31/11	$ 250.00	$ 250.00	$ 250.00	$ -
C	04/01/11	03/31/12	$ 300.00	$ -	$ 300.00	$ 300.00
D	07/01/11	06/30/12	$ 400.00	$ -	$ -	$ 400.00
E	10/01/11	09/30/12	$ 350.00	$ -	$ -	$ 350.00
F	01/01/12	12/31/12	$ 225.00	$ -	$ -	$ 225.00
Total			$1,725.00	$ 450.00	$ 750.00	$1,275.00

The calculation of in-force premium is slightly more complicated in the case of a mid-term adjustment. Assume Policy D (which is in-force from July 1, 2011 to June 30, 2012) is changed on January 1, 2012, and the applicable full-term premium increases from $400 to $800. This policyholder will ultimately pay $600 (=$400 x 0.5 + $800 x 0.5). The in-force premium is the full-term premium for the policy that is in-force at that point in time. So, the in-force premium is $400 for an in-force date between July 1, 2011, and December 31, 2011, and $800 for an in-force date between January 1, 2012, and June 30, 2012.

As in-force premium is the best estimate of the company's mix of business as of a given date, the most recent in-force premium is often used to measure the impact of a rate change on an existing portfolio of customers.

Policies Other Than Annual

The preceding example illustrated premium aggregation techniques assuming all policies are annual. If the policy terms are not annual, the aggregation concepts are applied the same way. Since the techniques associated with aggregating calendar year written and earned exposures on semi-annual policies were demonstrated in Chapter 4, they will not be repeated here with respect to premium.

Actuaries should interpret in-force premium carefully when considering (or comparing) portfolios that write policies with different terms. For example, if two insurers write the same volume of written premium, but one insurer writes annual term policies and the other writes semi-annual term policies, the in-force premium of the insurer writing semi-annual term policies will be half that of the other carrier. Adjustments can be made to make the companies' in-force numbers more comparable, but this detail is beyond the scope of this text.

Calculation of Blocks of Policies

In reality, companies write many more than six policies; consequently, actuaries often have to perform these aggregation techniques on many policies at once. In such a case, it is customary for the practitioner to treat all policies as if they were written at the mid-point of the period (such as the 15th of the month for monthly data); this practice is often referred to as the "15th of the month" rule. This is a good approximation as long as policies are written uniformly during each time period. If this approach is applied to longer periods (e.g., quarters or years), the assumption of uniform writings is less likely to be reasonable. This rule was discussed in detail in Chapter 4.

ADJUSTMENTS TO PREMIUM

In order for historical premium to be useful in projecting future premium, it must first be brought to current rate level. The policies underlying the experience period may have been written using rates that are no longer in effect. Adjustments need to be made to the historical premium for rate increases (decreases) that occurred during or after the historical experience period or the projected premium will be understated (overstated). This is referred to as adjusting the premium "to current rate level" or putting the premium "on-level." Two current rate level methods, extension of exposures and the parallelogram method, are described in detail in this section.

In addition to a current rate level adjustment, historical premium must be developed to ultimate. This is especially relevant in the case of analysis performed on incomplete policy years or premium that has yet to undergo audit. Historical premium should also be adjusted for actual or expected distributional changes. This is referred to as premium trend. One-step and two-step trending are discussed in detail in this section.

Current Rate Level

To illustrate the need for a current rate level adjustment, consider the simple scenario in which all policies were written at a rate of $200 during the historical period. After the historical period, there was a 5% rate increase so the current rate in effect is $210. Assume the "true" indicated rate for the future ratemaking time period is $220. If the practitioner fails to consider the 5% increase already implemented and compares the historical rate (i.e., $200) to the indicated rate (i.e., $220), the practitioner will conclude that rates need to be increased by 10%. Implementing this indicated rate change will result in a new rate of $231 (= $210 x 1.10), which is excessive. If instead, the practitioner restates the historical premium to the present rate level of $210 and compares that to the indicated rate, the practitioner will correctly deduce that rates only need to be increased 4.8% (= $220 / 210 - 1.00).

This section discusses two methods for adjusting premium to the current rate level: extension of exposures and the parallelogram method.

Simple Example

Before describing the two methods for adjusting premium to current rate level, the details underlying a simple rate change example will be summarized and later used to illustrate the mechanics of each method.

In this simple example, assume that all policies have annual terms and premium is calculated according to the following rating algorithm:

$$\text{Premium} = \text{Exposure} \times \text{Rate per Exposure} \times \text{Class Factor} + \text{Policy Fee}.$$

The class factor has three values, or levels (X, Y, and Z), each with a distinct rate differential.

The following three rate changes occurred during or after the historical experience period.

- July 1, 2010: the base rate was increased and this resulted in an overall average rate level increase of 5%.[13]
- January 1, 2011: the base rate and policy fee were adjusted resulting in an overall average rate level increase of 10%.
- April 1, 2012: the policy fee and class Y and Z rate relativities were changed resulting in an overall average rate level decrease of -1%.

The details of each rate level are as follows:

[13] The reader may be confused by the overall average rate changes provided in this example [e.g., how a 5.6% (=950/900-1.00) change in rate per exposure results in an overall average rate change of 5.0%]. The overall average rate change considers the average change in the total premium per policy, which is a function of the rate per exposure, the number of exposures per policy, the applicable class factors, and the policy fee. These detailed inputs have not been provided; the overall average rate change should be taken as a given for the purpose of illustrating premium at current rate level techniques.

5.15 Rate Change History

Rate Level Group	Effective Date	Overall Average Rate Change	Rate Per Exposure	Class Factor X	Class Factor Y	Class Factor Z	Policy Fee
1	Initial	--	$ 900	1.00	0.60	1.10	$ 1,000
2	07/01/10	5.0%	$ 950	1.00	0.60	1.10	$ 1,000
3	01/01/11	10.0%	$ 1,045	1.00	0.60	1.10	$ 1,100
4	04/01/12	-1.0%	$ 1,045	1.00	0.70	1.05	$ 1,090

Extension of Exposures

The extension of exposures method involves rerating every policy to restate the historical premium to the amount that would be charged under the current rates.

Extension of exposures has the advantage of being the most accurate current rate level method, assuming the actuary has access to the detailed data required. In the past, extension of exposures was practically impossible due to the significant number of calculations required to rerate each policy. Given the tremendous increase in computing power, the only remaining hurdle is associated with gathering the required data. To adjust premium to the current rate level using the extension of exposures technique, the practitioner needs to know the applicable rating characteristics for every policy in the historical period. Often companies do not have that information readily available.

Returning to the example, assume the actuary wishes to adjust the historical premium for Policy Year 2011 to the current rate level. Assume one such policy was effective on March 1, 2011 and had 10 class Y exposures. The actual premium charged for the policy was based on the rates effective on January 1, 2011, and was $7,370 (= 10 x $1,045 x 0.60 + $1,100). To put the premium on-level, substitute the current base rate, class factor, and policy fee in the calculations; this results in an on-level premium of $8,405 (= 10 x $1,045 x 0.70 + $1,090). This same calculation is performed for every policy written in 2011 and then aggregated across all policies.

If a group of policies has the exact same rating characteristics, they can be grouped for the purposes of the extension of exposures technique. This type of grouping is—practically speaking—only relevant in lines with relatively simple rating algorithms and very few rating variables.

In some commercial lines products, underwriters can apply subjective debits and credits to manual premium. This complicates the use of the extension of exposures technique since it may be difficult to determine what debits and credits would be applied under today’s schedule rating guidelines. The actuary may consider measuring how credit and debit practices have changed by reviewing distributions of debits and credits over recent years.

Parallelogram Method

The parallelogram method, which is sometimes called the geometric method, is undertaken on a group of policies and is less accurate than extension of exposures. The method assumes that premium is written evenly throughout the time period, an assumption that should be evaluated with each analysis. The parallelogram method involves adjusting the aggregated historical premium by an average factor to put the premium on-level. Application of the method varies by policy term, method of aggregation (calendar year versus policy year), and whether the rate change affects policies midterm or only policies with effective dates occurring after the change. Examples of each are provided.

Standard Calculations

The objective of the parallelogram method is to replace the average rate level for a given historical year with the current rate level. The major steps for the parallelogram method are as follows:

1. Determine the timing and amount of the rate changes during and after the experience period and group the policies into rate level groups according to the timing of each rate change.
2. Calculate the portion of the year's earned premium corresponding to each rate level group.
3. Calculate the cumulative rate level index for each rate level group.
4. Calculate the weighted average cumulative rate level index for each year.
5. Calculate the on-level factor as the ratio of the current cumulative rate level index and the average cumulative rate level index for the appropriate year.
6. Apply the on-level factor to the earned premium for the appropriate year.

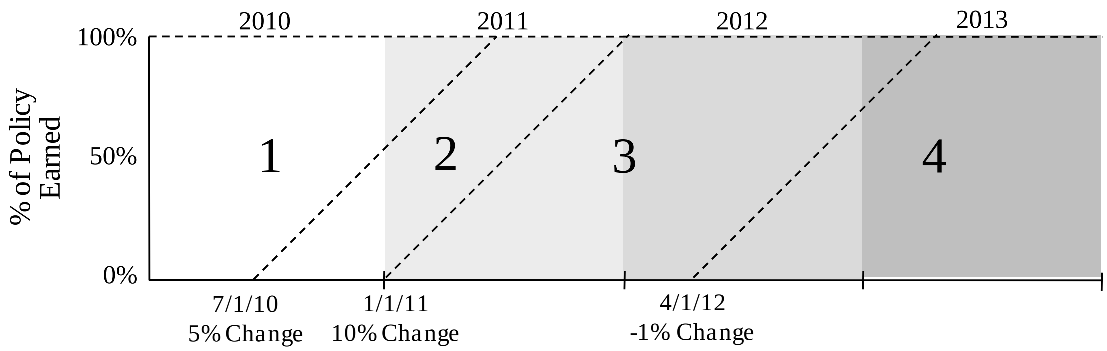
For the parallelogram method, the exact rates are not required as the calculations only use the overall average percent rate changes. Returning to our example, Table 5.16 contains the relevant information for Step 1: the effective date and overall rate change amount for four different rate level groups. In this example, the policies are annual and the rate changes apply to policies effective on or after the date (i.e., do not apply to policies in mid-term).

5.16 Step 1

Rate Level Group	Effective Date	Overall Average Rate Change
1	Initial	--
2	07/01/10	5.0%
3	01/01/11	10.0%
4	04/01/12	-1.0%

For Step 2, it is helpful to view these rate changes in graphical format. Assume the actuary is trying to adjust each calendar year's earned premium to current rate level. As noted earlier in the chapter, calendar years are represented by squares. The rate changes in this example only impact policies written on or after the effective date; therefore, each rate change is represented by a diagonal line. The slope of the diagonal line depends on the term of the policy; the example shown assumes annual policies. The numbers 1, 2, 3, and 4 represent the rate level group in effect.

5.17 Rate Changes assuming CY EP with Annual Policies

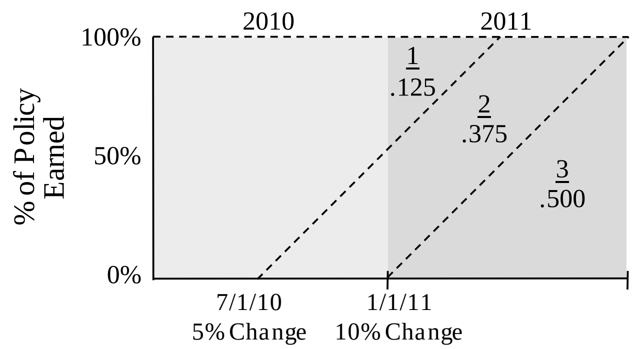


Once the picture is drawn, the next step is to calculate the portion of each calendar year's earned premium (the area within the square) that corresponds to each unique rate level group. Considering Calendar Year 2011, there are three areas: the area representing earned premium on policies written after January 1, 2010 and prior to the July 1, 2010 rate change (area of rate level group 1 in Calendar Year 2011), the area representing earned premium on policies written on or after July 1, 2010 and before January 1, 2011 (area of rate level group 2 in Calendar Year 2011), and the area representing earned premium on policies written on or after January 1, 2011 and before January 1, 2012 (area of rate level group 3 in Calendar Year 2011). Simple geometry,[14] as well as the assumption that the distribution of policies written is uniform over time, is used to calculate the portion of the square represented by each rate level area. For example, area 1 in Calendar Year 2011 is a triangle with area equal to ½ x base x height. The base and height are both six months (January 1, 2011 to June 30, 2011) so the area (in months) is 18 (= ½ x 6 x 6). This area's portion of the entire calendar year square is 0.125 (=18 / (12 x 12)). The math is simplified if restating the base and height as portions of a year (0.125 = ½ x ½ x ½). Also, some areas (e.g., area 2 in Calendar Year 2011) are easier to calculate as one minus the sum of the remaining areas. The areas of the three rate levels in Calendar Year 2011 are summarized below:

- Area 1 in CY 2011: 0.125 = 0.50 x 0.50 x 0.50
- Area 2 in CY 2011: 0.375 = 1.00 - (0.125 + 0.500)
- Area 3 in CY 2011: 0.500 = 0.50 x 1.00 x 1.00

[14] The following geometric formulae may be used in the parallelogram method:
Area of a triangle: ½ x base x height
Area of a parallelogram: base x height
Area of a trapezoid: ½ x ($base_1$ + $base_2$) x height

5.18 Areas in 2011 assuming CY EP with Annual Policies)



Step 3 of the procedure involves determining the cumulative rate level index for each distinct rate level group. The first rate level group is assigned the rate level of 1.00. The cumulative rate level index of each subsequent group is the prior group's cumulative rate level index multiplied by the rate level for that group. For example, the cumulative rate level index for the second rate level group is 1.05 (= 1.00 x 1.05). The third rate level group's cumulative rate level index is 1.155 (= 1.05 x 1.10). The following table shows the cumulative rate level indices for each group in our example.

5.19 Step 3

Rate Level Group	(1) Effective Date	(2) Overall Average Rate Change	(3) Rate Level Index	(4) Cumulative Rate Level Index
1	Initial	--	1.00	1.0000
2	7/1/10	5.0%	1.05	1.0500
3	1/1/11	10.0%	1.10	1.1550
4	4/1/12	-1.0%	0.99	1.1435

(4)= (Previous Row4) x (3)

Step 4, the calculation of the average rate level index for each year, is the weighted average of the cumulative rate level indices in Step 3, using the areas calculated in Step 2 as weights. For example, the average rate level index for Calendar Year 2011 is:

$$1.0963 = 1.000 \text{ x } 0.125 + 1.0500 \text{ x } 0.375 + 1.1550 \text{ x } 0.500.$$

Step 5 is the calculation of the on-level factor, defined as follows:

$$\text{On - Level Factor for Historical Period} = \frac{\text{Current Cumulative Rate Level Index}}{\text{Average Rate Level Index for Historical Period}}.$$

The numerator considers the most recent cumulative rate level index (i.e., not just the most recent within the historical experience period) from Step 3. The denominator is the result of Step 4.

For the simple example, the following is the on-level factor for Calendar Year 2011 earned premium, assuming annual policies:

$$1.0431 = \frac{1.1435}{1.0963}.$$

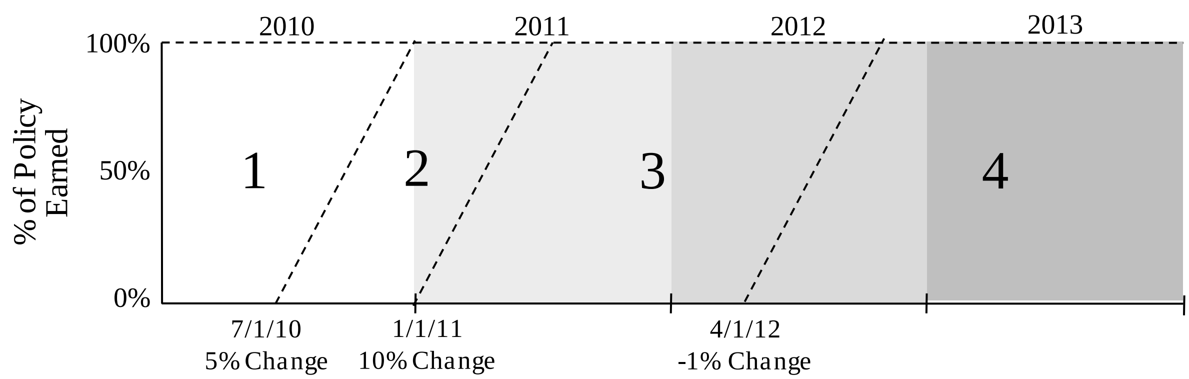
In Step 6, this on-level factor is applied to the Calendar Year 2011 earned premium in order to bring it to current rate level.

$$\text{CY11 EP at current rate level} = \text{CY11 EP x } 1.0431.$$

Standard Calendar Year Calculations for Six-Month Policies

If the policy term in the example is six months rather than annual (as is common in personal automobile coverage), then the pictorial representation of the rate level groups is as follows:

5.20 Rate Changes assuming CY EP with 6-Month Policies



In this case, the areas (Step 2) for Calendar Year 2011 are as follows:

- Area 1 in CY 2011: N/A
- Area 2 in CY 2011: 0.250 = 0.50 x 0.50 x 1.00
- Area 3 in CY 2011: 0.750 = 1.00 - 0.250

The cumulative rate level indices (Step 3) are the same as those used for the annual policies.

The following is the average rate level index (Step 4) for Calendar Year 2011 assuming semi-annual policies:

$$1.1288 = 1.0500 \times 0.250 + 1.1550 \times 0.750$$

The on-level factor (Step 5) to adjust Calendar Year 2011 earned premium to current rate level assuming semi-annual policies is:

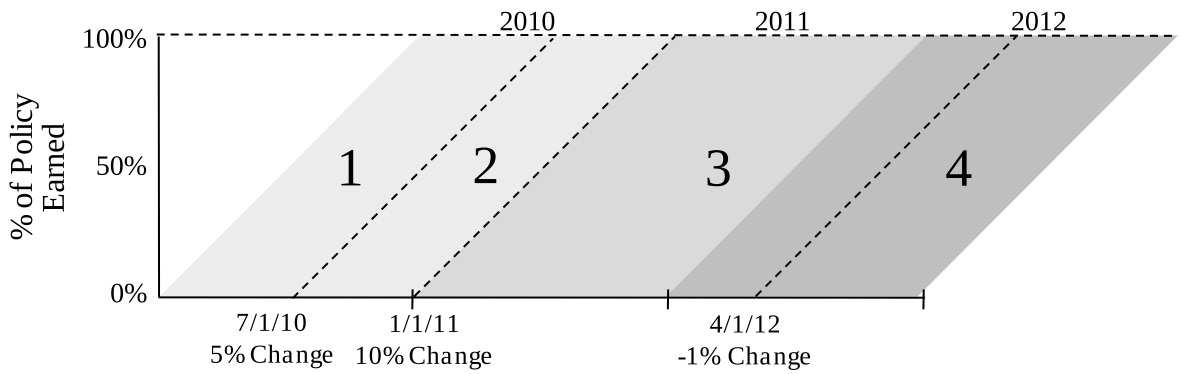
$$1.0130 = \frac{1.1435}{1.1288}.$$

The on-level adjustment for semi-annual policies is smaller than for annual policies because the semi-annual rate changes earn more quickly.

Standard Policy Year Calculations for Annual Policies

If the actuary is performing a policy year analysis, parallelograms are used instead of squares. The lines representing the rate changes are still diagonal. The following picture shows the policy year adjustment assuming the same rate changes and an annual policy term:

5.21 Rate Changes assuming PY EP with Annual Policies



As Policy Year 2011 has one rate level applied to the whole year, it is more helpful to show an example for Policy Year 2012, which has two rate level groups. The area of each parallelogram is base x height. For example, area 3 in Policy Year 2012 has a base of 3 months (or 0.25 of a year) and the height is 12 months (or 1.00 year). The relevant areas (Step 2) for Policy Year 2012 are as follows:

- Area 3 in PY 2012: 0.25 = 0.25 x 1.00
- Area 4 in PY 2012: 0.75 = 0.75 x 1.00

The cumulative rate level indices (Step 3) are the same as those used in the calendar year example.

The average rate level index (Step 4) for Policy Year 2012 is:

$$1.1464 = 1.1550 \times 0.25 + 1.1435 \times 0.75.$$

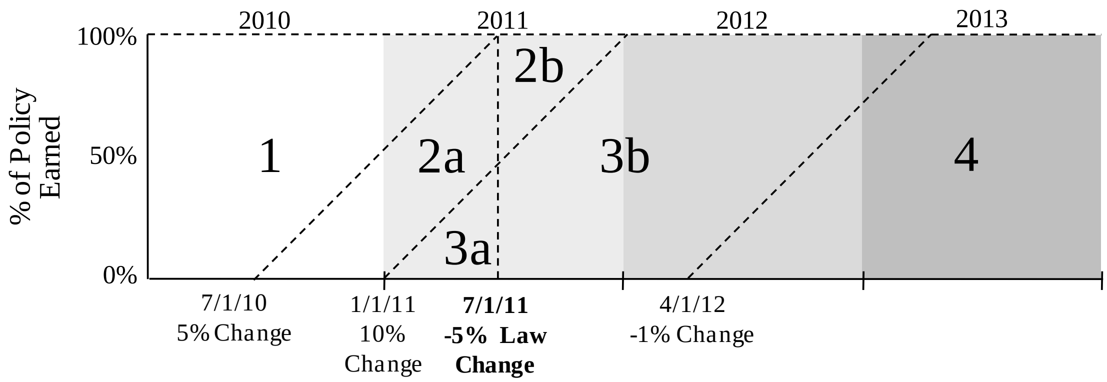
The following is the on-level factor (Step 5) to adjust Policy Year 2012 earned premium to current rate level:

$$0.9975 = \frac{1.1435}{1.1464}.$$

Rate Changes Mandated by Law

The previous example considers standard rate changes whereby the effective date of the rate change applies to policies effective on or after that date. In some cases, rate changes are in response to law changes that may mandate the rate change be applied to all policies on or after a specific date, even those that are currently in-force. In that special case, the rate level change is represented as a vertical line rather than a diagonal line. For illustrative purposes, assume a law change mandates a rate decrease of 5% on July 1, 2011, that is applicable to all policies, including policies currently in-force. Assuming annual policies and the standard rate changes laid out earlier, the pictorial representation is as follows:

5.22 Rate and Law Change assuming CY EP with Annual Policies



Notice that the vertical line splits rate level groups 2 and 3 into two pieces each. Applying standard geometry, the areas for this example are as follows:

- Area 1 in CY 2011: 0.125 = 0.50 x 0.50 x 0.50
- Area 2a in CY 2011: 0.250 = 0.50 - 0.125 - 0.125
- Area 2b in CY 2011: 0.125 = 0.50 x 0.50 x 0.50
- Area 3a in CY 2011: 0.125 = 0.50 x 0.50 x 0.50
- Area 3b in CY 2011: 0.375 = 0.50 - 0.125

The rate level indices are also affected by the inclusion of the -5% law change which impacts the rate level indices associated with the portion of areas 2b, 3b, and 4. The cumulative rate level indices associated with each group are as follows:

5.23 Step 3 with Benefit Change

Rate Level Group	Cumulative Rate Level Index
1	1.0000
2a	1.0500
2b	0.9975
3a	1.1550
3b	1.0973
4	1.0863

The on-level factor is still the current cumulative rate level index divided by the average cumulative rate level index of the historical period. For the example, the calculation is as follows:

$$1.0171 = \frac{1.0863}{1.0000 \times 0.125 + 1.0500 \times 0.250 + 0.9975 \times 0.125 + 1.1550 \times 0.125 + 1.0973 \times 0.375}.$$

The calculations associated with law changes in the case of semi-annual policies or policy year earned premium are the same, just with different geometric shapes.

Comments on the Parallelogram Method

There are two problems associated with the parallelogram method. The first issue is that the method assumes policies are written evenly throughout the year. While that assumption may be reasonable for some lines of business, it can be inappropriate for other lines. For example, boat owners policies are generally purchased in the first half of the year prior to the start of boat season. Thus, the distribution of inception dates for pleasure boat owners policies is generally not uniform throughout the year. The parallelogram method can be performed using more refined periods of time than a year—for example, quarters or months. This alleviates the effect of uneven earnings to some degree. Another technique to adjust for this is to calculate the actual distribution of writings and use these to determine more accurate weightings to calculate the historical average rate level. To do this, the policies are aggregated based on which rate level was applicable rather than based on a standard time period (i.e., a month, year, or quarter). The premium for each rate level group is adjusted together based on subsequent rate changes.

The second issue with the parallelogram method is that it is generally applied at the aggregate level using a series of overall average changes. So, while the overall premium may be adjusted to an approximated current rate level, the premium for certain classes will not be on-level if the implemented rate changes varied by class. Consequently, the adjusted premium will likely be unacceptable for any classification ratemaking analysis. This is a major shortcoming that has forced many companies to abandon this approach in favor of the extension of exposures approach. This is especially true for lines with complex rating structures that are changed regularly, like personal lines automobile and homeowners.

Premium Development

In some cases, the actuary may not know the ultimate amount of premium for the experience period at the time the analysis is being performed. When this occurs, the actuary must estimate how the premium will develop to ultimate. Common scenarios include when an actuary is using an incomplete year of data or when the line of business uses premium audits.

Actuaries try to balance stability and responsiveness when determining the data to be used for a ratemaking analysis. At times, the actuary may feel it is prudent to use a year that is not yet complete; this is more common for policy year analysis due to the long time it takes for the policy year to close. Assume a ratemaking analysis is performed on policy year data before all policies written in that year have expired (e.g., Policy Year 2011 as of December 31, 2011). While the actuary knows which policies have been written, the actuary does not know which policies may have changes or be cancelled during the policy term. Thus, the actuary must estimate how premium will develop to ultimate. Typically this is done by analyzing historical patterns of premium development to better understand the effect of cancelations and mid-term amendments on the policy year premium.

Another example of premium development occurs in lines that utilize premium audits. Typically, the insured will pay premium based on an estimate of the total exposure. Once the policy period is completed and the actual exposure is known, the final premium is calculated. For example, workers compensation premium depends on payroll and the final workers compensation premium is determined by payroll audits about three to six months after the policy expires. Actuaries study the pattern of premium development, which can depend on several factors including:

- The type of plan permitted by the jurisdiction or offered by the carrier
- The stability of the historical relationship between the original premium estimate and the final audited premium
- Internal company operations (auditing procedures, marketing strategy, accounting policy, etc.).

Calendar year data is final at the end of the calendar year, whereas accident year and policy year data may still be developing. Thus, premium development factors to adjust for premium audits are necessary to determine the ultimate premium when analyzing policy year or accident year data.

Consider the policy year example below.

- A workers compensation carrier writes one policy per month in 2011.
- Estimated premium for each policy is booked at policy inception for $500,000.
- Premium on every policy develops upward by 8% at the first audit, six months after the policy expires.

At December 31, 2012, the six policies written in the first half of 2011 have completed their audits, but the six policies written in the second half of the year have not. The Policy Year 2011 premium as of December 31, 2012, is:

$$\$6,240,000 = 6 \times \$500,000 \times 1.08 + 6 \times \$500,000.$$

At December 31, 2013, all twelve policies have completed their final audits so the final premium is:

$$\$6,480,000 = 12 \times \$500,000 \times 1.08.$$

From December 31, 2012, (24 months after the start of the policy year) to December 31, 2013, (36 months after the start of the policy year), the premium development factor is

$$1.0385 \ (= \$6.48 \text{ million} / \$6.24 \text{ million}).$$

If this 24-36 month development pattern is relatively stable across other policy years, the actuary will feel confident adjusting future policy year premium at 24 months of development by this factor to bring the premium to its ultimate value.

Premium development does not typically apply to calendar year premium as calendar year implies premium is fixed. However, some actuaries may choose to adjust calendar year premium if audit patterns are changing and a calendar year analysis is being performed.

More information on workers compensation premium development can be found in Sholom Feldblum's paper, "Workers' Compensation Ratemaking" (Feldblum 1993).

Exposure Trend

Rate changes are not the only thing that can change the average premium level. In fact, the average premium level can change over time due to inflation in lines of business with exposure bases that are inflation-sensitive, like payroll (for workers compensation) or receipts (general liability). For lines of business using inflation-sensitive exposures bases, it is typical to project exposures (and thus premium) to future inflationary levels. The trends used for these projections can be estimated via internal insurance company data (e.g., workers compensation payroll data) or via industry or government indices (e.g., average wage index).

Premium Trend

In addition to inflationary pressure, the average premium level can change over time due to changes in the characteristics of the policies written. These changes are referred to as distributional changes, and the resulting change in average premium level is commonly referred to as premium trend.

The following are a few representative examples of circumstances that can cause changes in the average premium level:

- A rating characteristic can cause average premium to change. For example, homeowners premium varies based on the amount of insurance purchased. This variable is generally indexed such that it increases automatically with inflation; therefore, average premium increases as well.
- A company may decide to move all existing insureds to a higher deductible. Raising the deductible decreases the amount of coverage and, therefore, the premium charged. Assuming the company moves each insured to the higher deductible upon renewal and that the renewals are spread throughout the year, there will be a decrease in average premium over the entire transition period. The trend will not be expected to continue once the transition is complete.
- One company may purchase the entire portfolio of another company. If the new risks are somewhat different than the existing book of business, that can lead to a very abrupt one-time change in the average premium. For example, if a typical homeowners insurer acquires a book of business that includes predominantly high-valued homes, the acquisition will cause a very abrupt increase in the average premium due to the increase in average home values. After the books are consolidated, no additional shifts in the business are expected.

Since the goal of ratemaking is to determine adequate rates for the future, it is important to adjust the historical premium to the level expected during the future time period. In addition to adjusting the historical premium to the current rate level, the premium also must be adjusted to reflect any premium trend. To adjust for premium trend, the actuary needs to determine how to measure any changes that have occurred, decide whether observed distributional shifts were caused by a one-time event or a shift that is expected to continue in the future, and judgmentally incorporate any additional shifts that are reasonably expected to happen in the future.

The actuary may consider examining how premium distributions by individual rating variable have shifted over time. However, this may not always be practical or conclusive. Such distributional data may not be readily available, or the actuary may find that several variables have experienced small premium shifts and the compound effect is difficult to quantify. Consequently, the analysis usually focuses on measuring all premium shifts simultaneously.

Actuaries typically examine changes in historical average premium per exposure to determine an appropriate adjustment to account for premium trend. Actuaries do not use changes in total premium because a company that is growing (or shrinking) will have increasing (or decreasing) total premium even if the distribution of types of policies remains consistent. The average premium should be calculated on an exposure basis rather than a policy basis, and it is important to calculate the average premium using the exposure base that underlies the rate.

The actuary also must decide whether to use earned or written premium. Earned premium is used in most other parts of the ratemaking analysis and may seem like a more natural choice; however, written premium data reflects shifts in the distribution more quickly than earned premium does. In other words, written premium is a leading indicator of trends that will eventually emerge in earned premium and as such, the trends observed in written premium are appropriate to apply to historical earned premium. Assuming an adequate amount of data, the actuary will often use quarterly average written premium (as opposed to annual average written premium) to make the statistic as responsive as possible.

The following table shows data typically used to estimate premium trend due to distributional changes:

5.24 Change in Average WP

(1) Quarter	(2) Written Premium at Current Rate Level	(3) Written Exposures	(4) Average Written Premium at Current Rate Level	(5) Annual Change
1Q09	$ 323,189.17	453	$ 713.44	--
2Q09	$ 328,324.81	458	$ 716.87	--
3Q09	$ 333,502.30	463	$ 720.31	--
4Q09	$ 338,721.94	468	$ 723.76	--
1Q10	$ 343,666.70	472	$ 728.11	2.1%
2Q10	$ 348,696.47	477	$ 731.02	2.0%
3Q10	$ 353,027.03	481	$ 733.94	1.9%
4Q10	$ 358,098.58	485	$ 738.35	2.0%
1Q11	$ 361,754.88	488	$ 741.30	1.8%
2Q11	$ 367,654.15	493	$ 745.75	2.0%
3Q11	$ 372,305.01	497	$ 749.10	2.1%
4Q11	$ 377,253.00	501	$ 753.00	2.0%

(4) = (2) / (3)
(5) = (4) / (Prior Year4) - 1.0

The annual changes in average written premium are used to determine the amount the historical premium needs to be adjusted to account for premium trend. Note the premium used for this table has already been adjusted to the current rate level. If that is not done, the data will show an abrupt change in the average written premium corresponding to the effective date of the rate change. Allowing that change to influence the premium trend selection essentially adjusts for current rate level twice (once in the explicit current rate level adjustment and once in trend).

There are two methods for adjusting historical data for premium trend: one-step and two-step trending.

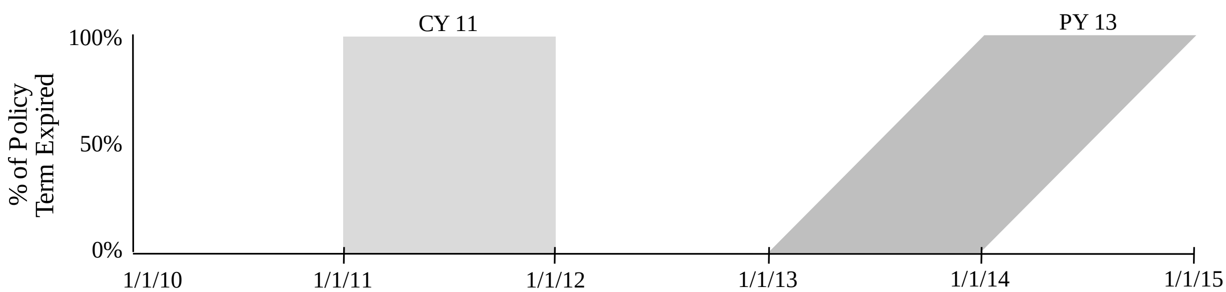
One-Step Trending

The basic one-step trending approach involves the selection of a premium trend based on the historical changes in average premium. Sometimes the actuary fits an exponential or linear trend to the data[15] to guide the selection; however, as the changes in average written premium are normally pretty consistent from one time period to the next, curve-fitting is usually not necessary. The selected trend factor is used to adjust the historical premium to the expected levels after consideration of distributional shifts.

Based on the data in Table 5.24, the actuary may make a trend selection of 2%. This is the amount the actuary expects the average premium to change annually. The actuary needs to determine the length of time the trend should be applied (i.e., the trend period). Assuming the ratemaking analysis uses written premium as the basis of the trend selection and earned premium for the overall rate level indications (which is standard), the trend period is typically measured as the length of time from the average written date of policies with premium earned during the historical period to the average written date for policies that will be in effect during the time the rates will be in effect.

Consider the case that the actuary uses Calendar Year 2011 earned premium for the analysis to estimate the rate need for annual policies that are to be written during the period of January 1, 2013 through December 31, 2013. Using concepts described earlier, this can be represented with the following figure:

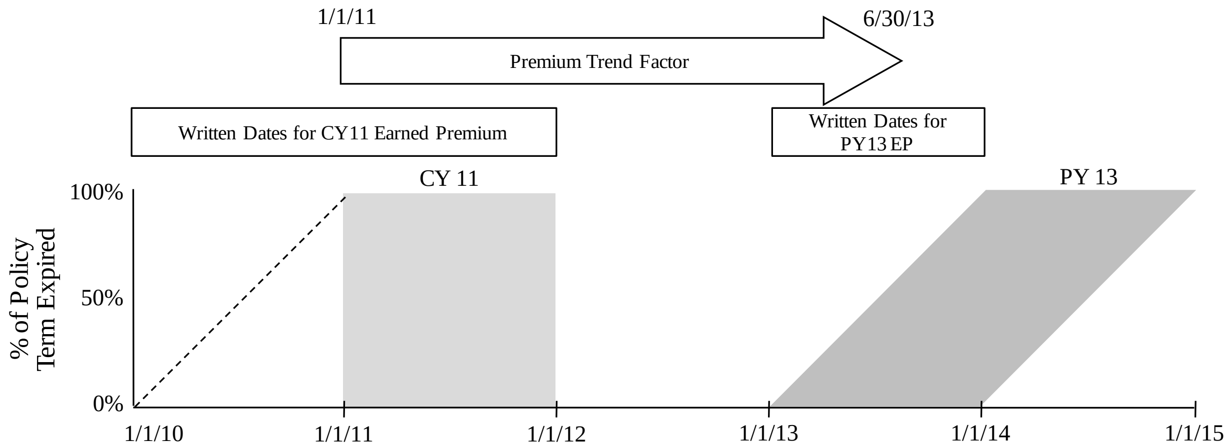
5.25 Historical and Projected Periods



The Calendar Year 2011 earned premium contains premium from policies that were written almost one year prior to the start of the calendar year (i.e., January 2, 2010) through to policies that were written on the very last day of Calendar Year 2011 (i.e., December 31, 2011). Thus, the average written date for premium earned in Calendar Year 2011 is January 1, 2011. In the projected period, policies will be written from January 1, 2013, to December 31, 2013, making the average written date June 30, 2013. Actuaries often round to the nearest half-month when determining trend lengths; this practice alleviates the need to determine the true mid-point of the experience period. Given those dates, the trend period is 2.5 years (i.e., January 1, 2011 to June 30, 2013). The following figure displays this.

[15] This technique will be discussed more fully in the loss trend section of the chapter on Losses and LAE.

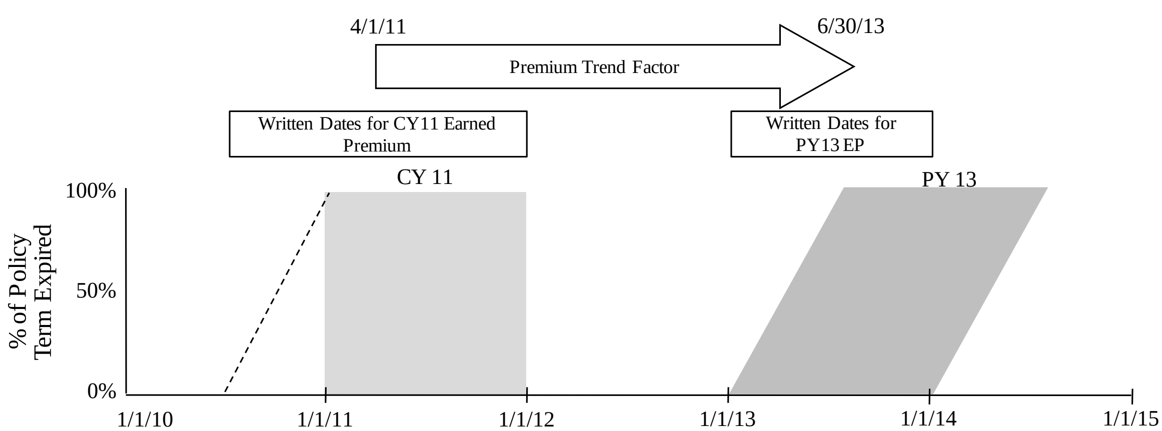
5.26 Trend Period for 12-month Terms



Alternatively, some companies determine the trend period as the length of time from the average date of premium earned in the experience period to the average date of premium earned in the projected period. Using the same annual policy term example, the average date of premium earned in the experience period is the midpoint of Calendar Year 2011, or July 1, 2011. The average date of premium earned in the projected policy year period is December 31, 2013. The trend period is still 2.5 years as each date was shifted by the same amount. Subsequent paragraphs in this chapter will refer to the first method of deriving premium trend length.

There are a few conditions that can affect the length of the premium trend period. First, if the actuary is reviewing policies that have a term other than 12 months, the average written date of policies earning in the calendar year (the "trend from" date) will be different than discussed above. For example, if the policies in the prior example were six-month policies, then the "trend from" date is April 1, 2011. The average written date of policies in the projection period (the "trend to" date) is unchanged (June 30, 2013), and the trend length is 2.25 years.

5.27 Trend Period for 1-Step Trending with 6-Month Policies



Second, if the historical premium is Policy Year 2011—rather than Calendar Year 2011—then the "trend from" date for annual policies is later and corresponds to the average written date for Policy Year 2011, or July 1, 2011. The "trend to" date does not change (June 30, 2013), and the trend length is 2 years.

Finally, if the proposed rates are expected to be in effect for more or less than one year, then the "trend to" date for annual policies will also be different than explained above. For example, if the proposed rates in the prior example are expected to be in effect for two years (from January 1, 2013 to December 31, 2014), then the "trend to" date for annual policies will be December 31, 2013, and the trend length is 3 years.

Given the original trend period calculated earlier of 2.5 years, the adjustment to Calendar Year 2011 earned premium to account for premium trend on annual policies is:

$$1.0508 \ (= (1.0 + 0.02)^{2.5}).$$

It is difficult to apply this approach when the changes in average premium vary significantly year-by-year and/or when the historical changes in average premium are significantly different than the changes that are expected in the future. For example, if the company had forced all insureds to a higher deductible at their first renewal on or after January 1, 2011, the shift would have been completed by December 31, 2011, and the observed trend will not continue into the future. When situations like this occur, companies may use a two-step trending approach.

Two-Step Trending

Two-step trending is also used in practice, especially when the company expects the premium trend to change over time. For example, some lines of business may require several historical years be used when projecting premium for ratemaking purposes. If the trend during that historical period has been significantly different from what is expected to occur in the future, it makes sense to adjust the historical data to current levels accordingly, but to apply a different trend into the forecast period to reflect what is expected to occur in the future. A particular example when the two-step trending process may be appropriate is when a homeowners insurer observes significant increases in amount of insurance during the experience period that are not expected to continue into the future.

In two-step trending, the actuary adjusts each year's historical premium to the average premium level of the most recent point in the trend data (this is called the current trend step), and then applies a separate adjustment to project this premium into the future policy period (this is called the projected trend step).

In Step 1, the actuary typically adjusts each year's historical premium to the current trend level by applying the following adjustment factor:

$$\text{Current Premium Trend Factor} = \frac{\text{Latest Average WP at Current Rate Level}}{\text{Historical Average EP at Current Rate Level}}.$$

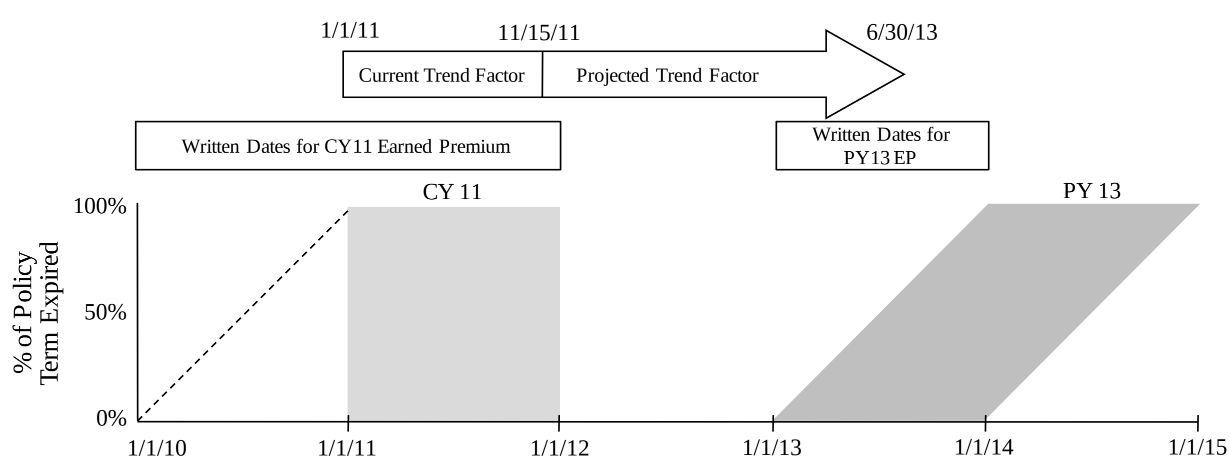
Assuming the average earned premium for Calendar Year 2011 is \$740.00, and the average written premium for the latest available quarter, Calendar Quarter 4Q2011, is \$753.00 (as shown in Table 5.24), then the current premium trend factor for Calendar Year 2011 is 1.0176 (= 753.00 / 740.00). In effect, this factor adjusts the historical Calendar Year 2011 earned premium to the average written date of the latest quarter available in the trend data. In our example, the latest average written premium data is for the fourth quarter of 2011; thus, the average written date is November 15, 2011. Note this will be the "project from" date for the second step in the process. Had the current average written premium been based on Calendar Year 2011 as opposed to the fourth quarter of 2011, then the average written date would have been June 30, 2011.

When the historical average premium is volatile, the actuary may choose to analyze several data points and select a current trend rather than use the ratio described above. For example, assume the selected current annual premium trend were 2%. The trend length is from the average written date of premium earned in the experience period (January 1, 2011, in the annual policy example) to the average written date of the latest period in the trend data (November 15, 2011, in the example), or 0.875 years. The Calendar Year 2011 earned premium would be adjusted by a current premium trend factor of 1.0175 (= $1.02^{0.875}$).

In Step 2, the actuary selects the amount the average premium is expected to change annually from the current level (as of November 15, 2011 in this example) to the level in the projected period. As in the one-step trending approach, the "trend to" date in this projection is the average written date during the period the proposed rates are expected to be in effect (June 30, 2013). Thus, the projected trend period is 1.625 years long (November 15, 2011, to June 30, 2013). Assuming the actuary selects a projected annual premium trend of -1%% (e.g., he has knowledge of a campaign to increase deductible amounts), the projected trend factor is 0.9838 (= $(1.0 - 0.01)^{1.625}$).

For convenience, the following picture depicts the two-step trending periods for the annual policy example.

5.28 Trend Period for 2-Step Trending on 12-month Policies



The total premium trend factor for two-step trending is the product of the current trend factor and the projected trend factor. For this example, that is 1.0011 (= 1.0176 x 0.9838). That number is applied to the average historical earned premium at current rate level to adjust it to the projected level:

CY11 Projected EP at Current Rate Level =
CY11 EP at Current Rate Level x Current Trend Factor x Projected Trend Factor.

For convenience, the calculations are included in the following chart.

5.29 Two-Step Trending

(1)	Calendar Year 2011 Earned Premium at Current Rate Level	$	1,440,788
(2)	Calendar Year 2011 Earned Exposures		1,947
(3)	Calendar Year 2011 Average Earned Premium at Current Rate Level	$	740.00
(4)	4th Quarter of 2011 Average Written Premium at Current Rate Level	$	753.00
(5)	Step 1 (Current) Trend Factor		1.0176
(6)	Selected Projected Premium Trend		-1.0%
(7)	Projected Trend Period		1.6250
(8)	Step 2 (Projected) Trend Factor		0.9838
(9)	Total Premium Trend Factor		1.0011
(10)	Projected Premium at Current Rate Level	$	1,442,373

(3) =	(1) / (2)
(5) =	(4) / (3)
(8) =	(1.0 + (6)) ^ (7)
(9) =	(5) x (8)
(10) =	(1) x (9)

SUMMARY

Estimating future premium is an important aspect of any loss ratio ratemaking analysis. Depending on the nature of the analysis, premium may be aggregated on a calendar year or policy year basis. Furthermore, the actuary may examine in-force premium, written premium, earned premium, unearned premium, or all of them.

When the actuary performs a loss ratio analysis, the actuary must project the premium that is expected during the time the proposed rates will be in effect. If the historical premium is used as a starting point for the projection, the actuary must adjust the historical premium for any rate changes, premium development, exposure trend (when applicable), and distributional shifts that occurred during or after the historical period. Failure to make these adjustments can seriously distort the loss ratio ratemaking analysis.

Appendices A-D provide realistic examples of ratemaking analysis, including the premium adjustments, that are intended to reinforce the concepts covered in this chapter.

KEY CONCEPTS IN CHAPTER 5

1. Premium aggregation
    a. Calendar year v. policy year
    b. In-force v. written v. earned v. unearned premium

2. Premium at current rate level
    a. Extension of exposures
    b. Parallelogram method

3. Premium development

4. Exposure trend

5. Premium trend
    a. One-step trending
    b. Two-step trending

CHAPTER 6: LOSSES AND LAE

As stated in Chapter 1, the fundamental insurance equation is:

Premium= Losses + LAE + UW Expenses + UW Profit.

The role of a pricing actuary is to estimate each of these components for the period during which the proposed rates will be in effect. The preceding chapter provided techniques for estimating the projected premium. Now attention is turned to the loss and loss adjustment expense components.

Amounts paid or owed to claimants under the provisions of an insurance contract are known as losses. Though some actuarial literature uses the terms losses and claims interchangeably, this text will use the term claim to refer to the demand for compensation, and loss to refer to the amount of compensation. A claimant can be the insured or a third party seeking damages covered under the terms of the insurance contract. Amounts paid by the insurance company to investigate and settle claims are called loss adjustment expenses (LAE). Losses and LAE usually represent the largest component of insurance costs and hence the largest portion of insurance premium. It is easy to understand why quantifying expected future loss and LAE costs are of utmost importance to the pricing actuary.

This chapter discusses:

- The different types of insurance losses
- How loss data is aggregated for ratemaking analysis
- Common metrics involving losses
- Adjustments made to historical loss data to make it relevant for estimating future losses in the context of ratemaking. This includes adjusting data for:
  - extraordinary loss events
  - changes in benefit levels
  - changes in the loss estimates as immature claims become mature
  - changes in loss cost levels over time
- Treatment of loss adjustment expenses

LOSS DEFINITIONS

Paid losses are those losses that have been paid to claimants. When a claim is reported to the insurance company and payment is expected to be made in the future, a **case reserve** for the expected amount is established on the claim. The case reserve may be based on a claims adjuster's estimate or may be determined by formula. The sum of paid losses and case reserves is referred to as **reported losses**, and is also known as **case incurred losses**. When reported losses are further adjusted to account for any anticipated shortfall in the case reserves (i.e., development on known claims, also known as incurred but not enough reported, or IBNER) and for claims that have not yet been reported (i.e., incurred but not reported, or IBNR), then the losses are referred to as estimated **ultimate losses**. These losses are an estimate of all of the payments the insurer will ultimately make to claimants, which is eventually a known quantity.

It is important to understand that aggregated loss measures are defined by a choice of relevant statistics (e.g., paid or reported losses), a data aggregation method (e.g., calendar, accident, policy, or report month/quarter/year), and a period of time. The period of time for data aggregation is defined by both an accounting period and a valuation date. The accounting period refers to the inventory of losses during a particular time, which is often consistent with financial statement dates—e.g., month, quarter, or calendar year. The valuation date, which can be different than the end of the accounting period, is the date as of which the losses are evaluated for analysis. It is often expressed as the number of months after the start of the accounting period (e.g., Accident Year 2010 as of 18 months implies Accident Year 2010 as of June 30, 2011). The valuation date can also be expressed relative to the end of the accounting period (e.g., six months after the close of Accident Year 2010). As valuation dates can occur prior to the end of the accounting period, the former approach is more common.

LOSS DATA AGGREGATION METHODS

As described in Chapter 3, four common methods of data aggregation are calendar year, accident year, policy year, and report year. The following summarizes each method as it pertains to aggregation of losses.

Calendar year aggregation considers all loss transactions that occur during the twelve-month calendar year without regard to the date of policy issuance, the accident date, or the report date of the claim. Calendar year paid losses include all payments made during the calendar year on any claims. Calendar year reported losses are equal to paid losses plus the change in case reserves during that twelve-month calendar year. At the end of the calendar year, all calendar year paid and reported losses are fixed.

Accident year aggregation considers all loss transactions for claims that have an occurrence date during the year[16] being evaluated, regardless of when the policy was issued or the claim was reported. Accident year paid losses are the sum of all payments made on any claims that occurred during the year (i.e., the date of accident is during that year). Accident year reported losses consist of all loss payments made plus the case reserves as of the valuation date for those claims that occurred during the year. Unlike calendar year losses, accident year losses can and do change after the end of the year as additional claims are reported, claims are paid, or reserves are changed. Since accident year is not closed (fixed) at the end of the year, future development of losses needs to be estimated.

Policy year aggregation, which is sometimes referred to as underwriting year, considers all loss transactions on policies that were written during the year, regardless of when the claim occurred or when it was reported, reserved, or paid. Policy year paid losses are the sum of all payments made on claims covered by policies written during the year. Policy year reported losses are the sum of the policy year paid losses and the case reserves as of the valuation date for claims covered by policies written during the year. Like accident year losses, policy year losses can and often do change as additional claims occur, claims are paid, or reserves are changed. Because a policy year extends until the last policy (which may be written on the last day of the year) expires, policy year claims associated with annual policies arise from a two year time period, a longer period than calendar year and accident year losses. Consequently,

[16] Some companies may aggregate losses in twelve-month periods that do not correspond to calendar years. This is generally called a fiscal accident year. In such cases, the period is referred to as 12 months ending mm/dd/yy (referred to as the accounting date).

the estimation of future development on known claims is subject to more uncertainty than accident year aggregation.

Report year is the fourth loss aggregation method. This method is similar to accident year except the losses are aggregated according to when the claim is reported, as opposed to when the claim occurs. The accident dates are maintained so the actuary can determine the lag in reporting, and the report year losses may be subdivided based on the report lag. By design, this type of aggregation results in no IBNR (incurred but not reported) claims, but a shortfall in case reserves (i.e., incurred but not enough reported, or IBNER) can exist. For standard ratemaking, report year aggregation is generally limited to the pricing of claims-made policies. Claims-made policies provide coverage based on the date the claim is reported, as opposed to the date the claim occurs. Companies may choose to write claims-made policies in lines of business for which there is often a significant lag between the date of the occurrence and the reporting of the claim (e.g., medical malpractice). Claims-made ratemaking is covered in more detail in Chapter 16.

The following example further illustrates quantifying reported losses under the different loss aggregation methods. Assume these are the only claims reported for this company and reserve levels are $0 prior to Calendar Year 2009.

6.1 Claim Transaction History

Policy Effective Date	Date of Loss	Report Date	Transaction Date	Incremental Payment	Case Reserve*
07/01/09	11/01/09	11/19/09	11/19/09	$0	$10,000
			02/01/10	$1,000	$9,000
			09/01/10	$7,000	$2,500
			01/15/11	$3,000	$0
09/10/09	02/14/10	02/14/10	02/14/10	$5,000	$10,000
			11/01/10	$8,000	$4,000
			03/01/11	$1,000	$0

*Case reserve evaluated as of transaction date.

The Calendar Year 2009 reported losses are $10,000. This is the Calendar Year 2009 paid losses (i.e., the sum of the losses paid in 2009 ($0)) plus the ending reserve at December 31, 2009 ($10,000), minus the beginning reserve in 2009 ($0).

The Calendar Year 2010 reported losses are $17,500. This is Calendar Year 2010 paid losses ($1,000 + $7,000 + $5,000 + $8,000) plus the ending reserve at December 31, 2010 ($2,500 + $4,000), minus the beginning reserve in 2010 ($10,000).

The Calendar Year 2011 reported losses are -$2,500. This is the Calendar Year 2011 paid losses ($3,000+$1,000) plus the ending reserve at December 31, 2011 ($0), minus the beginning reserve in 2011 ($2,500 + $4,000).

The Accident Year 2009 reported losses as of December 31, 2011, are $11,000, which considers transactions on the first claim only. This is the cumulative losses paid through December 31, 2011, on the first claim ($1,000 + $7,000 + $3,000) plus the case reserve estimate for this claim as of December 31, 2011 ($0). (When referring to Accident Year paid losses, the adjective *cumulative* is usually implied rather than explicit.)

The Accident Year 2010 reported losses as of December 31, 2011, are $14,000, which considers transactions on the second claim only. This is the losses paid on the second claim through December 31, 2011 ($5,000 + $8,000 + $1,000), plus the case reserve estimate for this claim as of December 31, 2011 ($0).

The Policy Year 2009 reported losses as of December 31, 2011, are $25,000, which considers transactions from both of these policies. This is the sum of the losses paid on both policies ($1,000 + $7,000 + $3,000 + $5,000 + $8,000 + $1,000), plus the case reserve estimate as of December 31, 2011 ($0).

The Policy Year 2010 reported losses as of December 31, 2011, are $0 since neither of these policies was issued in 2010.

Table 6.2 summarizes Calendar Year 2009, Accident Year 2009, and Policy Year 2009 reported losses at three different valuation points.

6.2 Reported Losses: CY09 v AY09 v PY09

	Valuation Date		
Aggregation Type	**12/31/2009**	**12/31/2010**	**12/31/2011**
Calendar Year 09	$10,000	$10,000	$10,000
Accident Year 09	$10,000	$10,500	$11,000
Policy Year 09	$10,000	$27,500	$25,000

The chart demonstrates that while the calendar year reported losses are finalized at the end of the year, accident year and policy year losses are not. In particular, policy year losses undergo significant development during the second twelve months of the 24-month policy year period. This longer lag time required to get accurate policy year estimates is considered a shortcoming of the policy year aggregation method.

The Report Year 2009 reported losses only include amounts associated with the first claim as it was reported in 2009. As of December 31, 2009, the Report Year 2009 reported losses are $10,000, which reflects the outstanding case reserve only as the paid losses at December 31, 2009, are $0. As of December 31, 2010, the Report Year 2009 reported losses are $10,500, which is the sum of all payments made ($1,000 + $7,000) and the $2,500 case reserve estimate as of the end of 2010. The second claim was reported in 2010 and, therefore, only contributes to Report Year 2010 losses.

COMMON RATIOS INVOLVING LOSS STATISTICS

Four common ratios involving loss statistics are: frequency, severity, pure premium, and loss ratio. As stated previously, each ratio is defined by a choice of relevant statistics (e.g., paid or reported losses, or earned or written premium), a data aggregation method (e.g., calendar, accident, policy, or report month/quarter/year), an accounting period, and a valuation date.

Frequency is a measure of claim incidence and is generally expressed per unit of exposure. Consider a private passenger automobile example. In a given calendar-accident year, an insurance company has 150,000 earned car years. As of six months after the close of the calendar year, it is known that 7,500 claims occurred during the calendar-accident year. The calendar-accident year reported claim frequency as of 18 months is 7,500 / 150,000 = 0.05. The numerator of this ratio can be expressed in various ways (e.g., reported, paid, or closed claims). Also, a decision should be made whether to include claims that closed without payment.

Severity is a measure of the average loss per claim. If the 7,500 claims above produced $18,750,000 of reported losses as of 18 months, the reported severity as of 18 months is $2,500 (= $18,750,000 / 7,500). The two components of this ratio, losses and claims, can be described and aggregated in various ways—e.g., paid or reported losses; reported, paid, or closed claims with or without claims that closed without payment. In addition, actuaries pricing certain lines of business may use losses developed to ultimate in their severity measures (loss development adjustments will be covered later in this chapter). The ratemaking actuary should give careful thought to how to define severity and be clear in communications to avoid confusion.

Pure premium (also known as loss cost or burning cost) is a measure of the average loss per exposure. It is calculated as the total losses divided by total exposures; this is equivalent to the product of frequency and severity. As with frequency and severity, this calculation involves a choice of relevant statistics. The choice should be consistent with those in the underlying frequency and severity ratios (e.g., if paid claims were used as the numerator of frequency, they should also be used as the denominator of severity). In the example above, the pure premium as of 18 months is $18,750,000 / 150,000 = $125 = 0.05 x $2,500.

Loss ratio is the ratio of losses (or losses and LAE) to premium, which measures the portion of each premium dollar needed to pay losses (or to pay losses and LAE). This metric varies depending on the types of premium and loss used, and the method of aggregation; furthermore, the numerator may or may not include loss adjustment expenses or be developed to ultimate loss levels. As mentioned previously, it is very important to clearly communicate how a particular metric is defined. The most common loss ratio metric is reported loss ratio, or reported losses divided by earned premium. Continuing the example outlined above, if premium earned during the calendar year is $32,000,000, the calendar-accident year reported loss ratio as of 18 months is 58.6% (= $18,750,000 / $32,000,000).

ADJUSTMENTS TO LOSSES

Losses need to be projected to the cost level expected when the rates will be in effect. This is typically done using historical losses with a series of adjustments. Preliminary adjustments may involve removing extraordinary events (e.g., individual shock losses and catastrophe losses) from historical losses and replacing them with a provision more in line with long-term expectations. Immature losses also need to be developed to reflect their ultimate settlement value. Further adjustments may be applied to restate losses to the benefit and cost levels expected during the future policy period.

This text will not prescribe a specific order for the various adjustments to historical losses. The actuary needs to consider how each adjustment is derived in order to assess the order of application. For example, if a catastrophe model outputs ultimate catastrophe losses expected in the future policy period, this provision should be added to non-catastrophe losses that have already been trended and developed to ultimate. If the catastrophe provision is added to non-catastrophe losses, and the sum is then trended and developed, the expected catastrophe losses will be over-adjusted.

Though a particular order for adjustments is not prescribed in this text, several examples of rate level indications (including the various adjustments to losses) for different lines of business are included in the appendices of this text.

Extraordinary Losses

Large Individual Losses

Excessively large individual losses happen infrequently but are somewhat expected in the insurance world. Examples of such losses, also referred to as shock losses, may include a large multi-claimant liability claim, a total loss on an exceptionally high-valued home, and a total permanent disability of a young worker. For many large companies, the size of the portfolio can dwarf the effects of shock losses, but shock losses in a smaller portfolio can introduce instability to the ratemaking process.

If actual shock losses are included in the ratemaking analysis as is, indicated rates may increase immediately after a year with shock losses and may decrease when there are no shock losses present in the experience period. Consequently, historical data used to project future losses may exclude these losses in their entirety or, more typically, may just exclude the portion above some predetermined threshold. Losses are later modified by a provision to incorporate expected shock losses based on a long-term view.

In some cases, the threshold for capping shock losses may be based on the minimum amount of insurance offered, often called the "basic limit" as it corresponds to the limit associated with the base rate. When this approach is used, the rate level indication (which will be discussed in detail in Chapter 8) is the rate level need assuming all insureds choose the basic limit. Consequently, the premium used in the rate level indication[17] must also be adjusted to the basic limit (i.e., each exposure's premium rerated as if the basic limit was purchased). The effect of the losses other than the basic limit will be considered in the classification ratemaking analysis (which will be discussed in detail in Chapter 11).

Ideally, the large loss threshold should correspond to the point at which the losses are extraordinary and their inclusion causes volatility in the rates; in some cases, that point may be significantly higher than the basic limit. For example, the basic limit for personal automobile liability insurance typically equals the amount of insurance required by the financial responsibility laws. As many insureds voluntarily select higher limits of insurance, large insurers may have a significant number of losses that exceed the basic limit.

When the losses are not capped at the basic limit, the actuary must determine the large loss threshold that best balances the following goals: including as many losses as possible and minimizing the volatility in the ratemaking analysis. One approach is to examine the size of loss distribution and set the threshold at a given percentile, such as the 99th percentile. This can be done by examining individual claim sizes in increasing order and choosing the claim amount for which 99% of the claim inventory is below that amount. Alternatively, a threshold can be chosen with respect to a certain percentage of losses rather than claim counts. For some insurance products, the amount of insurance varies based on the value of the

[17] As discussed in Chapter 8, rate level indications can be performed on a loss ratio or pure premium basis. Only the loss ratio method uses premiums in the calculation; therefore, this adjustment to basic limits premium is only necessary if performing a loss ratio indication.

insured item (e.g., property insurance). In these cases, the expected size of loss distribution may vary significantly from one policy to the next, and it may be more appropriate to use a threshold that is a percentage of the amount of insurance than to use a fixed threshold.

In terms of the fundamental insurance equation, indicated rates will be understated if actual shock losses have been removed from projected losses and no provision for shock losses has been added. The actual shock loss is typically replaced with an average expected large loss amount that is calculated based on a longer term view of the effect of such events. The length of time used to determine the true effect of such events may vary significantly for different lines of business and even from insurer to insurer. For example, a medium-sized homeowners insurer may derive a good estimate for expected large fire losses using 10 years of data, while a small personal umbrella insurer may need 20 years of data. The actuary also wants to avoid using too many years as older data becomes less relevant over time (e.g., jury awards may be much higher today than previously). If there are no data limitations, the average should be based on the number of years necessary to produce a stable and reasonable estimate without including so many years as to make the historical data irrelevant.

The following example shows a simple procedure that caps individual reported losses at $1,000,000 (these capped losses are referred to as non-excess losses) and uses the long-term average ratio of excess losses (the portion of each shock loss above the $1,000,000 threshold) to non-excess losses to determine an excess loss provision. The assumption implicit in this procedure is that while the proportion of losses attributable to extraordinary losses will be volatile in the short-run, the proportion will be stable when viewed over a sufficiently long period of time.

6.3 Excess Loss Procedure

	(1)	(2)	(3)	(4)	(5)	(6)
Accident Year	Reported Losses	Number of Excess Claims	Ground-Up Excess Losses	Losses Excess of $1,000,000	Non-Excess Losses	Excess Ratio
1996	$ 118,369,707	5	$ 6,232,939	$ 1,232,939	$ 117,136,768	1.1%
1997	$ 117,938,146	1	$ 1,300,000	$ 300,000	$ 117,638,146	0.3%
1998	$ 119,887,865	3	$ 3,923,023	$ 923,023	$ 118,964,842	0.8%
1999	$ 118,488,983	0	$ -	$ -	$ 118,488,983	0.0%
2000	$ 122,329,298	7	$ 12,938,382	$ 5,938,382	$ 116,390,916	5.1%
2001	$ 120,157,205	3	$ 3,824,311	$ 824,311	$ 119,332,894	0.7%
2002	$ 123,633,881	0	$ -	$ -	$ 123,633,881	0.0%
2003	$ 124,854,827	1	$ 3,000,000	$ 2,000,000	$ 122,854,827	1.6%
2004	$ 125,492,840	0	$ -	$ -	$ 125,492,840	0.0%
2005	$ 127,430,355	6	$ 13,466,986	$ 7,466,986	$ 119,963,369	6.2%
2006	$ 123,245,269	3	$ 4,642,423	$ 1,642,423	$ 121,602,846	1.4%
2007	$ 123,466,498	0	$ -	$ -	$ 123,466,498	0.0%
2008	$ 129,241,078	10	$ 17,038,332	$ 7,038,332	$ 122,202,746	5.8%
2009	$ 123,302,570	0	$ -	$ -	$ 123,302,570	0.0%
2010	$ 123,408,837	3	$ 4,351,805	$ 1,351,805	$ 122,057,032	1.1%
Total	$ 1,841,247,359	42	$ 70,718,201	$ 28,718,201	$ 1,812,529,158	1.6%
			(7) Excess Loss Factor			1.016

(4)= (3) - [$1,000,000 x (2)]
(5)= (1) - (4)
(6)= (4) / (5)
(7)= 1.0 + (Tot6)

The excess loss factor in Row 7 is applied to the non-excess losses for each year in the historical experience period.

Later in this chapter the issue of loss trending is discussed. This is the process of adjusting historical losses for time-related influences such as inflation in order to project losses to the future policy period. The simple excess loss procedure outlined above is ideally performed on reported losses that have been trended to future levels. In other words, excess losses are calculated by censoring trended ground-up losses.[18] Losses in higher layers of insurance are often subject to greater inflationary pressure than losses in lower layers. Ignoring this effect introduces some bias in the excess loss procedure. More detail regarding this leveraging effect is covered later in this chapter as well.

In addition to the simple procedure outlined above, some actuaries may fit statistical distributions to empirical data and simulate claim experience in order to calculate the expected excess losses.

Catastrophe Losses

Similarly, ratemaking data often excludes losses arising from catastrophic events. Unlike shock losses that are individual high severity claims, a catastrophe denotes a natural or man-made disaster that is

[18] Alternatively, the excess loss threshold can be indexed to reflect trend, and then applied to ground-up losses that have not been trended.

unusually severe and results in a significant number of claims. This can include hurricanes, tornadoes, hail storms, earthquakes, wildfires, winter storms, explosions, oil spills and certain terrorist attacks—though this list is hardly exhaustive.

In the U.S., the Property Claims Services (PCS) unit of the Insurance Services Office (ISO) currently defines catastrophes as events that cause $25 million or more in direct insured losses to property and that affect a significant number of policyholders and insurers. Insurance companies may have alternative definitions for their own internal procedures.

Like shock losses, catastrophe losses are typically removed from ratemaking data to avoid distorting effects in any ratemaking analysis. In the process of projecting future losses, the actual catastrophe losses are replaced with an average expected catastrophe loss amount. The method used to calculate such a provision varies by type of insurance, or more specifically by the type of catastrophic loss to which the line of business is exposed. The type of catastrophic loss is often broken down into non-modeled catastrophe losses and modeled catastrophe losses.

Non-modeled catastrophe analysis is generally undertaken on events that happen with some regularity over a period of decades. For example, the most common catastrophic loss related to private passenger automobile comprehensive coverage (which covers most forms of physical damage to the insured's car other than collision) is hail storms. These storms happen with some mid-term regularity though loss projections based on a short experience period (e.g., three to five years) may lead to ratemaking instability. Without a catastrophe procedure, indicated rates will increase immediately after a bad storm year and decrease in years when no or few storms occur.

Similar to the excess loss procedure, the actuary can calculate the ratio of hail storm losses to non-storm losses over a longer experience period (e.g., 10-30 years). As discussed with the shock losses, the number of years used for this procedure should balance stability and responsiveness. For example, if the concentration of exposures in the most hail-prone area of a state has increased drastically over the past 20 years, then a catastrophe procedure based on 20 years of statewide data may understate the expected catastrophe potential. Once determined, the ratio can be used to adjust the non-catastrophe losses in consideration of future expected catastrophe loss.

Alternatively, the actuary can develop a pure premium (or loss ratio) specifically for the non-modeled catastrophe exposure. In the pure premium case, the actuary could examine the long-term ratio of cat losses to exposure (or to some inflation-sensitive measure like amount of insurance years) and apply that ratio to projected exposures (or projected amount of insurance years). Appendix B provides an example of deriving a non-modeled catastrophe pure premium. The loss ratio indication would be similar except the denominator of the long-term ratio would be earned premium, which is inflation-sensitive (though perhaps not to the same degree as the catastrophe losses), and the premium would need to be brought to current rate level.

Catastrophe models are generally used to account for events that are extremely sporadic and generate high severity claims, such as hurricanes and earthquakes. Even thirty years of data may not capture the correct expectation of the damage these events can inflict. For these types of catastrophes, sophisticated stochastic models are designed by professionals from a variety of fields (e.g., insurance professionals, meteorologists, engineers) to estimate the likelihood that events of varying magnitudes will occur and the damages that will likely result given the characteristics of the insured properties. The model is then used to estimate the expected annual catastrophe loss based on the insurer's exposure. The catastrophe loss provision produced by the model is simply added to the non-catastrophe loss amount to determine the aggregate expected losses to be used for pricing.

In most years, the actual catastrophe losses will be less than the expected annual provision, but in years with a major event or events, the actual losses will be significantly higher than the expected annual provision.

Companies typically monitor the number of policies in catastrophe-prone areas and may use non-pricing actions to control the concentration to minimize the financial impact any one event can have on the profitability of the company. For example, the company may restrict the writing of any new business, may require higher deductibles for catastrophe-related losses, or may purchase reinsurance. In addition to these non-pricing actions, the actuary may alter the underwriting profit provision in the rates to reflect the higher cost of capital needed to support the extraordinary risk caused by the higher concentration of policies.

More detailed discussion of catastrophe models and the effect on rates is beyond the scope of this text.

Reinsurance

Reinsurance is insurance purchased by primary insurance companies to transfer some of the financial risk they face. Historically, actuaries performed ratemaking analysis for primary insurance on a direct basis (i.e., without consideration of reinsurance). As reinsurance programs have become more extensive and reinsurance costs have increased substantially for some lines of business, some ratemaking analyses are now performed on a net basis (i.e., with consideration of reinsurance).

Reinsurance can be split between proportional and non-proportional covers. Proportional means the same proportion of premium and losses are transferred or "ceded" to the reinsurer; consequently, proportional reinsurance may not necessarily need to be explicitly included in the pricing consideration.

With non-proportional reinsurance, the reinsurer agrees to assume some predefined portion of the losses (which are the reinsurance recoverables). The insurer cedes a portion of the premium (which is the cost of the reinsurance). Common examples of non-proportional reinsurance include catastrophe excess-of-loss reinsurance (e.g., the reinsurer will cover 50% of the losses that exceed $15,000,000 up to $30,000,000 on their entire property book of business in the event of a catastrophe) and per risk excess-of-loss reinsurance (e.g., the reinsurer will cover the portion of any large single event that is between $1,000,000 and $5,000,000 for specified risks).

Typically, the projected losses are reduced for any expected non-proportional reinsurance recoveries. Of course, the cost of purchasing the reinsurance must be recognized, too. That is typically done by reducing the total premium by the amount ceded to the reinsurer. Alternatively, the net cost of the non-proportional reinsurance (i.e., the cost of the reinsurance minus the expected recoveries) may be included as an expense item in the overall rate level indication.

Changes in Coverage or Benefit Levels

An insurance policy provides benefits in the case of a covered event. The insurance company may initiate changes in coverage; for example, a company may expand or contract coverage with respect to the types of losses covered or may opt to increase or decrease the amount of coverage offered. Benefit levels can also be impacted by a law change or court ruling. Examples of this include caps on punitive damages for auto liability coverage and changes in the workers compensation statutory benefit levels.

In consideration of the fundamental insurance equation, future projected losses need to reflect the coverage/benefit levels expected during the time that rates will be in effect. Benefit changes can have both direct and indirect effects on losses. Direct effects, as the name implies, are a direct and obvious consequence of the benefit change. Indirect effects, on the other hand, arise from changes in claimant behavior that are a consequence of the benefit change; these are usually much more difficult to quantify than direct effects. The pricing actuary needs to understand the benefit change and its anticipated direct effect and, if possible, the indirect effect in order to adjust losses accordingly. Ideally, the historical loss data will be available by individual claim so that each claim can be restated to be consistent with the new benefit levels. This restatement can be incredibly cumbersome and therefore impractical. Other alternatives include studying the average restatement effect of groups of claims (e.g., by type of injury) or simulating loss data under the new benefit conditions.

Consider the following examples to better understand the quantification of benefit changes.

6.4 Limit Change

Claim number	(1) Losses Capped @$5,000	(2) Losses Capped @$3,000	(3) Effect of Change
1	$ 1,100	$ 1,100	0.0%
2	$ 2,350	$ 2,350	0.0%
3	$ 3,700	$ 3,000	-18.9%
4	$ 4,100	$ 3,000	-26.8%
5	$ 5,000	$ 3,000	-40.0%
6	$ 5,000	$ 3,000	-40.0%
Total	$ 21,250	$ 15,450	-27.3%

(1) Given
(2) = Min[(1), $3,000]
(3) = (2) / (1) - 1.0

Insurance companies determine the amount of coverage provided by a policy, either as a specified amount or a range of options for the policyholder. Assume the company reduces the maximum amount of coverage for jewelry, watches, and furs on a standard homeowners policy (referred to as the "inside limit") from $5,000 to $3,000. The direct effect of this change is that any claimants with jewelry, watches, and furs losses in excess of $3,000 will now only receive $3,000 rather than at most $5,000. The direct effect of this change can be easily calculated if a distribution of historical jewelry, watches, and furs losses is available. Table 6.4 shows the how the reported losses on six claims would be capped under the two different thresholds.

Given the data provided, the expected direct effect is equivalent to -27.3%, which is the ratio of all such losses capped at $3,000 to all such losses capped at $5,000, minus 1.0. If the revision were to increase the limit to $6,000 (rather than decrease it), the data provided does not have enough information since all losses were capped at the current inside limit of $5,000. In such cases, the ratemaking actuary may need to consult claims studies to obtain the gross losses.

In addition to the direct effect of a coverage change described above, there may be an indirect effect, too. Consider the example involving a decrease in coverage. Insureds who previously relied on the coverage provided under their homeowners policy may feel the reduced coverage is inadequate and consequently purchase a personal articles floater (PAF) to cover jewelry, watches, and furs. If the homeowners coverage is secondary to the PAF, the jewelry, watches, and furs losses from the homeowners policy will be further reduced as they are now covered by the PAF. As there is no way to know how many insureds will purchase the PAF and the amount of PAF coverage they will purchase, it is very difficult to accurately quantify the indirect effect.

Workers compensation benefits are governed by statutes and changes in these statutes can lead to direct and/or indirect effects on losses. For example, statutes dictate the maximum/minimum benefits, the maximum duration of benefit, the types of injuries or diseases covered, treatments that are allowed, the administrative procedures to be followed, etc. Consider the case where the workers compensation wage replacement rate increases from 60% to 65% of pre-injury wages. If this is the only change, there is a direct effect as all workers will have their wages replaced at a higher rate; the direct effect on wage replacement losses is easily quantified as +8.3% (= 65% / 60% - 1.0). There may also be an indirect benefit as workers may be more inclined to file claims and claimants may have less incentive to return to work in a timely manner. This is difficult to quantify accurately and may require the actuary's professional judgment.

Consider another example where the workers compensation maximum indemnity benefit for a particular state is changing. The assumptions include:

- The compensation rate is 66.7% of the worker's pre-injury wage.
- The state average weekly wage (SAWW) is currently $1,000.
- The minimum indemnity benefit remains at 50% of the SAWW.
- The maximum indemnity benefit is decreasing from 100% of the SAWW to 83.3% of the SAWW.
- The distribution of workers (and their wages) according to how their wages compare to the SAWW is as follows:

6.5 Benefit Example

Ratio to Average Weekly Wage	# Workers	Total Weekly Wages
<50%	7	$ 3,000
50-75%	24	$ 16,252
75-100%	27	$ 23,950
100-125%	19	$ 23,048
125-150%	12	$ 16,500
>150%	11	$ 17,250
Total	100	$ 100,000

The key to determining the direct effect is to calculate the benefits provided before and after the change.

Currently, the minimum benefit is 50% of the SAWW. Since the SAWW is $1,000, the minimum benefit is $500 (= $1,000 x 50%). Given the current compensation rate of 66.7%, the minimum benefit of $500 will be applicable to all workers who earn less than 75% of the SAWW (i.e., $500 = 66.7% x 75% x $1,000). There are 31 (= 7 + 24) employees in that category; the aggregate benefits for those 31 employees is $15,500 (= 31 x $500).

The current maximum benefit is 100% of the SAWW, or $1,000. Given the current compensation rate of 66.7%, the maximum benefit of $1,000 will be applicable to the workers who earn more than 150% of the SAWW (i.e., $1,000 = 66.7% x 150% x $1,000). The 11 employees who are subjected to the current maximum benefit constitute $11,000 (= 11 x $1,000) in benefits.

The remaining 58 (= 27 + 19 + 12) employees fall between the minimum and maximum benefits. This means their total benefits are 66.7% of their actual wages or $42,354 (= (66.7% x 23,950) + (66.7% x 23,048) + (66.7% x 16,500)).

Under the current benefit structure, the sum total of benefits is $68,854 (= $15,500 + $11,000 + $42,354).

Once the statute changes and the maximum benefit is reduced from 100% to 83.3% of the SAWW, more workers will be subjected to the new maximum benefit. Specifically workers earning approximately 125% or more of the SAWW will be subjected to the maximum (i.e., $833.75 = (66.7% x 125% x $1,000) > $833). These 23 (= 11 + 12) workers will receive $19,159 (= 23 x $833) in benefits.

The number of workers affected by the minimum benefit, 31, is not impacted by the change. Their benefits remain $15,500.

Because more workers are now impacted by the maximum, there are now only 46 (= 27 + 19) employees that receive a benefit equal to 66.7% of their pre-injury wages or:

$31,348 (= (66.7% x 23,950) + (66.7% x 23,048)).

The new sum total of benefits is $66,007 (= 19,159 + 15,500 + 31,348). The direct effect (or expected change in benefits) from revising the maximum benefit is calculated by comparing the benefits before and after the change in maximum benefit; this is estimated at -4.1% (= 66,007 / 68,854 – 1.0).

6.6 Benefit Example

(1) Ratio to Average Weekly Wage	(2) # Workers	(3) Total Weekly Wages	(4) Current Benefits	(5) Proposed Benefits
<50%	7	$ 3,000	$ 3,500	$ 3,500
50-75%	24	$ 16,252	$ 12,000	$ 12,000
75-100%	27	$ 23,950	$ 15,975	$ 15,975
100-125%	19	$ 23,048	$ 15,373	$ 15,373
125-150%	12	$ 16,500	$ 11,006	$ 9,996
>150%	11	$ 17,250	$ 11,000	$ 9,163
Total	100	$ 100,000	$ 68,854	$ 66,007
		(6) Benefit Change		-4.1%

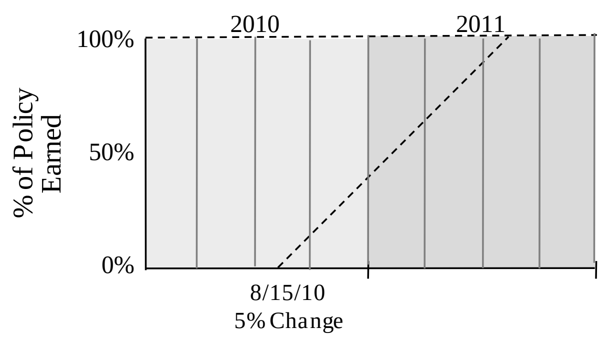
(4) =	<Min:	(2) x $500
	Other:	(3) x 0.667
	>Max:	(2) x $1,000
(5) =	<Min:	(2) x $500
	Other:	(3) x 0.667
	>Max:	(2) x $833
(6) =	(Tot5) / (Tot4) - 1.0	

If the maximum indemnity benefit is decreased, there may also be an indirect effect. The strength of the indirect effect is a function of the economic environment and the nature of the insured population, among other things. Assuming there is no data to estimate the indirect effect, it needs to be determined judgmentally.

Once the effect of the benefit change is quantified, the ratemaking actuary must consider the timing and details of the benefit change in order to adjust the historical data. For example, a benefit change may affect all claims on or after a certain date or claims arising from all policies written on or after the date. The necessary adjustment is different in each of those cases.

Techniques for calculating the appropriate adjustment are similar to the parallelogram method for deriving on-level premium in the previous chapter on premium. Figure 6.7 shows a law change implemented on August 15, 2010 that only affects losses on policies written on or after August 15, 2010. The direct effect of the change for annual policies on an accident year basis is estimated at +5%.

6.7 Affects Losses on New Annual Policies (AY Basis)



Since the law change is only applicable to losses on policies written after the implementation date, the line dividing the losses into pre- and post-change is a diagonal line representing a policy effective on the date of the law change. Note that the calendar-accident years have been divided into accident quarters. Recall that the parallelogram method assumes a uniform distribution of written premium (or in this case, of losses). The uniform distribution assumption may not be appropriate for losses that are affected by seasonality; therefore, it is prudent to measure loss adjustments at a more refined level than years. Similar to the on-level premium adjustment factor, the benefit change loss adjustment factor is:

$$\text{Adjustment} = \frac{\text{Current Loss Level}}{\text{Average Loss Level of Historical Period}}.$$

In the example displayed, the pre-change loss level is 1.00 and post-change loss level is 1.05. Focusing on the third quarter of 2010, the portion of losses assumed to be pre- and post-change are as follows:

- 3Q 2010 Post-change: 0.0078 = 0.50 x 0.125 x 0.125
- 3Q 2010 Pre-change: 0.2422 = 0.25 - 0.0078

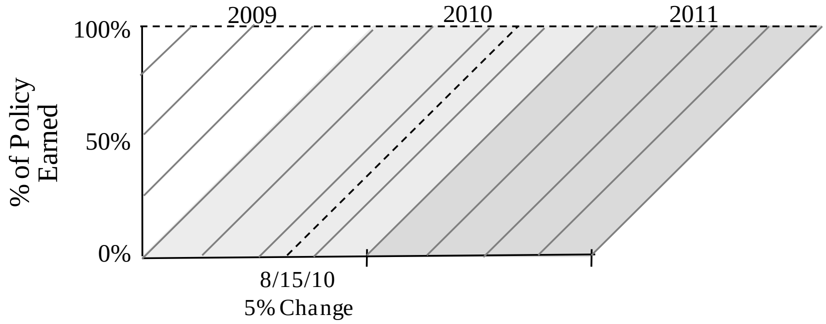
Consequently, the adjustment factor for third quarter 2010 reported losses is

$$\text{Adjustment} = \frac{1.05}{1.00 \times \left(\frac{0.2422}{0.2500}\right) + 1.05 \times \left(\frac{0.0078}{0.2500}\right)} = 1.0484.$$

The adjustment factors for the reported losses from all other quarters are calculated similarly.

Figure 6.8 shows how to measure the same law change on a policy year basis.

6.8 Affects Losses on New Annual Policies (PY Basis)



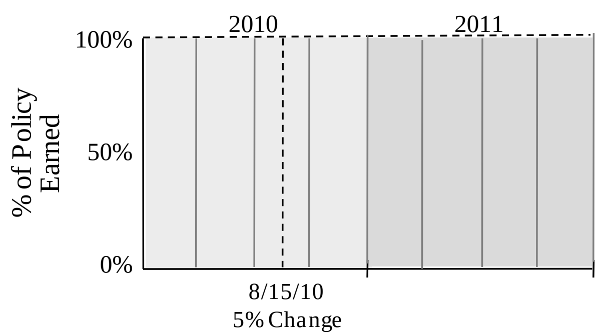
Using the same techniques, the adjustment factor applicable to the third quarter 2010 policy quarter reported losses is:

$$\text{Adjustment} = \frac{1.05}{1.00 \times \left(\frac{0.50 \times 0.25}{0.25}\right) + 1.05 \times \left(\frac{0.50 \times 0.25}{0.25}\right)} = 1.0244.$$

The reported losses from quarters prior to the third quarter need to be adjusted by a factor of 1.05. The reported losses from quarters after the third quarter are already being settled in accordance with the new law, so no adjustment is necessary.

The following figures show a benefit change that affects losses on claims that occur on or after August 15, 2010, regardless of the effective date of the policy. Figures 6.9 and 6.10 are the accident year and policy year representations, respectively.

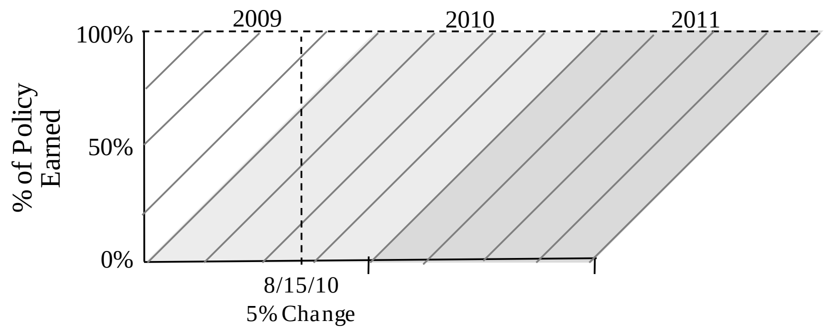
6.9 Affects all New Losses (AY Basis)



The adjustment factor that is applicable to third accident quarter 2010 losses is as follows:

$$\text{Adjustment} = \frac{1.05}{1.00 \times \left(\frac{0.50 \times 0.25}{0.25}\right) + 1.05 \times \left(\frac{0.50 \times 0.25}{0.25}\right)} = 1.0244.$$

6.10 Affects all New Losses (PY Basis)



The adjustment factor that is applicable to third policy quarter 2010 losses is as follows:

$$\text{Adjustment} = \frac{1.05}{1.00 \times \left(\frac{0.0078}{0.2500}\right) + 1.05 \times \left(\frac{0.2422}{0.2500}\right)} = 1.0015.$$

In addition to internal analysis of the effect of benefit changes, actuaries can access industry sources as well. For example, the National Council on Compensations Insurance (NCCI) publishes estimated industry effects of benefit level changes at the state level.

More detailed information on adjustments for benefit changes in workers compensation insurance can be found in Sholom Feldblum's "Workers' Compensation Ratemaking" (Feldblum 1993).

Loss Development

The cost for the insurance product, unlike other industries, is not fully known when the contract is provided or even when a claim is first reported. As a claim matures, payments are made and claim adjusters gather more information about the value of the loss until the final payment is made and the ultimate amount is known. For lines of business that settle claims quickly ("short-tailed lines," examples of which include automobile physical damage and homeowners) the ultimate amount is known rather quickly. In contrast, for some long-tailed lines (e.g., commercial general liability, workers compensation, or personal umbrella) it may take many years for the ultimate amount to be known.

As the ratemaking actuary typically uses the most recent accident year data available, the historical losses are to some degree immature and therefore the ultimate loss amount is not yet known. This is more pronounced if policy year data is used. The process of adjusting immature losses to an estimated ultimate value is known as loss development. Much of the vast library of property/casualty actuarial literature has been devoted to this topic. Explaining and comparing all known methods is beyond the scope of this text, but a cursory explanation of one commonly used method, the chain ladder method, is provided below.

The **chain ladder method** is based upon the assumption that aggregate losses will move from unpaid to paid in a pattern that is generally consistent over time; hence, historical loss development patterns can be used to predict future loss development patterns. The general mechanics of the method can be performed separately on claim counts and losses to generate ultimate values of each. For ratemaking purposes, the ultimate losses are the main concern, but a review of claim emergence and settlement patterns can shed light on how losses are developing.

The analysis can be done on various definitions of claims (e.g., reported, open, closed) and losses (e.g., paid and reported), and can also be applied to study patterns of allocated loss adjustment expenses. For ratemaking purposes in most lines of business, the general interest is the development of reported losses including allocated loss adjustment expenses.

The analysis should be undertaken on a body of homogeneous claims. This may imply a line of business or something more granular (e.g., coverages or types of losses within that line of business). Liability claims and property claims are typically analyzed separately. Experience by geography (e.g., state) may also be analyzed separately where there is sufficient volume. As will be discussed later in this section, the extraordinary losses should be removed and the losses should be adjusted for any material benefit changes.

Claims data or loss data for this method is usually organized in a triangle format as shown in Table 6.11. Each row is a different accident year. The columns represent each accident year's reported losses at successive maturities, starting at 15 months and increasing in annual increments. In this example, losses are assumed to be at ultimate levels at 75 months, so no more columns are required. Note, for some lines of business, ultimate may not be attained for several more years. Each diagonal represents a date as of which the evaluation of losses is made (the valuation date). For example, the latest diagonal represents a valuation date of March 31, 2008.

6.11 Loss Development Triangle

	Reported Losses ($000s) by AY Age (months)					
Accident Year	**15**	**27**	**39**	**51**	**63**	**75**
2002	1,000	1,500	1,925	2,145	2,190	2,188
2003	1,030	1,584	2,020	2,209	2,240	
2004	1,061	**1,560**	2,070	2,276		
2005	1,093	1,651	2,125			
2006	1,126	1,662				
2007	1,159					

The boxed value is the reported losses for accidents occurring in 2004 at 27 months of maturity (i.e., the losses paid and case reserves held as of March 31, 2006 for accidents occurring in 2004). Even before development patterns are calculated, the actuary may review the magnitude of losses at that first development age, 15 months, to determine whether loss levels at this early stage are generally consistent from year to year, with consideration for loss trends and any changes in the portfolio. If loss levels are dramatically different than expected, it may be prudent to examine a similar triangle of claim counts to see if a significantly larger or smaller than usual number of claims was reported for a particular accident year. Alternatively, inconsistent patterns in the losses at the first development period may be expected for small portfolios or long-tailed lines of business.

The development pattern is then analyzed by taking the ratio of losses held at successive maturities. This ratio is referred to as the link ratio or the age-to-age development factor. The following data triangle shows the link ratios for each accident year row as well as the arithmetic average, the geometric average,[19] and the volume-weighted average (the ratio of total reported losses at successive maturities[20] across all accident years):

6.12 Age-to-Age Loss Development Factors

	Age-to-Age Development Factors				
Accident Year	**15-27**	**27-39**	**39-51**	**51-63**	**63-75**
2002	1.50	1.28	1.11	1.02	1.00
2003	1.54	1.28	1.09	1.01	
2004	**1.47**	1.33	1.10		
2005	1.51	1.29			
2006	1.48				
2007					
Arithmetic average	1.50	1.30	1.10	1.02	1.00
Geometric average	1.50	1.29	1.10	1.01	1.00
Ratio of total losses	1.50	1.29	1.10	1.02	1.00
Selected factor	1.50	1.30	1.10	1.02	1.00

The boxed value shows that losses for Accident Year 2004 increased (or developed) 47% (= 1.47 – 1.0) from age 15 months to age 27 months.

The ratemaking actuary selects a suitable link ratio for each maturity, as shown in the table above. In this example, the link ratios for each development period are fairly consistent across the accident years and the all-year arithmetic average link ratios are selected.

In practice, age-to-age development factors may not be as stable as in the example outlined above and therefore simply averaging all of the historical link ratios may not be appropriate. First, if the ratemaking actuary believes the patterns may be changing over time, the actuary may prefer to rely on more recent development patterns rather than the average over a long period of time. In such cases, the actuary may select a two- or three-year average. Second, in some cases the actuary may want to make selections based on the most recent data, but the line of business may be too volatile to rely solely on a two- or three-year average. The actuary may calculate weighted average link ratios giving more weight to the more recent years. Third, development factors may vary widely between accident years or there may be a strong anomaly in one or two accident years. The actuary may consider adjusted averages that eliminate the highest and lowest development factors from the calculation. In general, the actuary should make loss development selections according to what is expected to occur in future periods.

It should be noted that reported losses tend to develop upward as losses approach ultimate. This is due in part to the emergence of new claims as well as adverse development on known claims. However, there are some lines of business where development may actually move in the opposite direction. In automobile physical damage coverages, an insurance company may declare a vehicle a total loss (i.e., pay the total limit for the car) and take the damaged car into its ownership. The damaged vehicle can then be sold as scrap or for parts. The money received in this transaction is called “salvage” and is treated as a negative loss.

[19] The geometric average is the *n*th root of the product of *n* numbers.
[20] The “ratio of total reported losses at successive maturities” compares the sums of an equal number of losses from each maturity (i.e., the most recent losses for the earlier maturity are not considered).

Another way development can be negative is through subrogation. Insurance companies sometimes pay losses for which another party is actually liable. After the losses are paid, the company can then approach the responsible party for indemnification of those amounts. When subrogation or salvage are common, age-to-age development factors can be less than 1.00. Development factors for reported losses can also be less than 1.00 when early case reserves are set too high.

This particular example assumes losses are ultimate at 75 months. For some lines of business, the historical data triangle may not reach ultimate. In that case, actuaries may fit curves to historical development factors to extrapolate the development beyond the patterns in the historical data or perform special studies that include more years of data. The factor that accounts for any additional development beyond that included in the standard chain ladder method is referred to as a "tail factor."

It is important that loss development patterns are reviewed carefully by the ratemaking actuary. The actuary should have knowledge of the line of business being analyzed, particularly the history of the claims handling procedures and any known events that could create an anomaly in the pattern.

The next step is to calculate age-to-ultimate development factors for each maturity. The age-to-ultimate development factor is the product of each selected age-to-age development factor and the selected age-to-age development factors for subsequent maturities (and the tail factor, if relevant). For example, the age-to-ultimate development factor for losses at age 51 months is the product of the selected age-to-age development factors for 51-63 months and 63-75 months (1.02 x 1.00).

These age-to-ultimate development factors are then applied to the reported losses at the most recent period of development (the latest diagonal in the reported loss triangle) to yield the estimated ultimate losses for each accident year, which are shown below:

6.13 Adjusting Reported Losses to Ultimate

Accident Year	(1) Accident Year Age (Months a/o 3/31/08)	(2) Reported Losses ($000s) a/o 3/31/08	(3) Age-to-Ultimate Development Factor	(4) Estimated Ultimate Losses ($000s)
2002	75	$ 2,188	1.00	$ 2,188
2003	63	$ 2,240	1.00	$ 2,240
2004	51	$ 2,276	1.02	$ 2,322
2005	39	$ 2,125	1.12	$ 2,380
2006	27	$ 1,662	1.46	$ 2,427
2007	15	$ 1,159	2.19	$ 2,538
Total		$ 11,650		$ 14,095

(4) = (2) x (3)

Extraordinary losses should be removed from the historical data used to measure loss development patterns. If an extraordinary loss is reported immediately and the ultimate amount is accurately reflected within the accident year reported losses as of 15 months, its inclusion will likely dampen the 15-27 month development pattern for that accident year.[21] If, on the other hand, the extraordinary loss is reported six months after the end of the accident year, then there will be a large jump in aggregate reported losses from 15 to 27 months, and the 15-to-27 month link ratio will be artificially high for that accident year.

Benefit or coverage changes may also distort loss development patterns. Benefit changes typically affect policies prospectively; in such cases, the effect of the change will first appear in a new accident year row. If the change impacts all claims occurring on or after a certain date, then it is possible that there will be a dramatic change in the absolute amount of losses even though the development pattern is unaffected. In the rare case that the change affects all claims not yet settled regardless of the date the loss occurred, then it may result in a shift of the aggregate loss amounts on a diagonal, which will distort the link ratios. If it is not possible to restate the losses, then any such distortions should be considered during the age-to-age development factor selection process.

The chain ladder method is only one method for calculating loss development. As mentioned earlier, the basic assumption of the chain ladder method is that the historical emergence and payment patterns are indicative of patterns expected in the future. In practice, these assumptions may not hold true. Changes in claims handling methodology or philosophy or even dramatic changes in claims staffing may result in claims being settled faster or slower than historical precedents, and this would violate the basic assumption of the chain ladder method.

In practice, actuaries use a variety of methods to develop losses to ultimate. Some methods, such as Bornhuetter-Ferguson, incorporate a priori assumptions of the expected loss ratio in order to calculate ultimate losses and consequently the outstanding reserve at a point in time. The Bornhuetter-Ferguson method is used in Appendix C. Other methods are used under particular circumstances. For example, the Berquist-Sherman method is often used when a company has experienced significant changes in claim settlement patterns or adequacy of case reserves that would distort development patterns. The method produces adjusted development patterns that are estimated to be consistent with the reserve levels and settlement rates present as of the last diagonal by restating historical development data. Stochastic methods, such as the Mack method, study the variability around loss development so actuaries can better understand the risk of adverse development. These methods are covered in more detail in literature regarding loss reserving methodologies.

In many insurance companies, different professionals may be responsible for estimating ultimate losses for the purposes of ratemaking verses establishing adequate reserve levels. Though the applications are different, the goal of estimating ultimate losses is the same. It is important that these professionals share knowledge of data, methods, and results in order to ensure consistent management of the company.

Loss Trend

In addition to projecting historical losses to an ultimate level, it is necessary to adjust the losses for underlying trends expected to occur between the historical experience period and the period for which the rates will be in effect. Claim frequencies and claim costs are both impacted by underlying factors that may change expected levels over time. These changes in frequency and severity are referred to as loss

[21] This assumes the estimate of the extraordinary loss is reasonably accurate and will change less drastically (as a percentage) than the non-excess losses. If the extraordinary loss increases by more than the normal losses, then the 15-27 month factor will actually be increased.

trends. The actuary should use the available data to estimate the loss trends in an effort to project the historical losses into the future.

Loss Trend Selections

Monetary inflation, increasing medical costs, and advancements in safety technology are examples of factors that can drive loss trends. Social influences also impact loss costs. Actuarial Standard of Practice No. 13, Trending Procedures in Property/Casualty Insurance Ratemaking (Actuarial Standards Board of the American Academy of Actuaries 2009) defines social influences as “the impact on insurance costs of societal changes such as changes in claim consciousness, court practices, and legal precedents, as well as in other non-economic factors.” Distributional changes in a book of business also affect frequencies and severities. If the proportion of risky policies is growing, loss costs will be expected to increase.

Actuaries generally measure loss trend by fitting curves to historical data. In addition to analyzing pure premium data, frequency and severity are typically analyzed separately to better understand the underlying drivers of the trend. For example, if an insurance company heavily markets a higher deductible, the resulting shift in distribution will lower frequencies but is likely to increase severities. It may be difficult to detect these changes in a pure premium analysis.

The years chosen to be included in the historical data is based on the actuary’s judgment, in consideration of both responsiveness and stability. Though the aim of the analysis is to detect the true underlying trend, influences such as the cyclical nature of insurance and random noise may be difficult to eliminate from the trend analysis. The actuary should, however, adjust the trend data for more easily quantifiable effects such as seasonality and the effect of benefit level changes, which will be addressed later.

Actuaries working in different lines of business may look at different or multiple views of the losses for analyzing trend. In more stable, short-tailed lines of business (e.g., automobile physical damage), the actuary typically analyzes calendar year paid losses for the 12 months ending each quarter. Calendar year data is readily available, the paid loss definition eliminates any distortion from changes in case reserving practices, and the use of 12-month rolling data attempts to smooth out the effect of seasonality. An actuary working on a more volatile and often long-tailed line of business (e.g., workers compensation medical) typically analyzes the trend in accident year reported losses that have already been developed to ultimate and adjusted for benefit changes.

Similar to loss development, it is prudent to undertake the trend analysis on a body of homogeneous claims; this may imply a line of business or something more granular (e.g., separating indemnity and medical losses within workers compensation insurance). Liability claims and property claims are typically analyzed separately. Experience by geography (e.g., state) may also be analyzed separately.

Regardless of loss definition used, frequency, severity, and pure premium are calculated for each time period and the change from period to period is analyzed. Linear and exponential regression models are the most common methods used to measure the trend in the data. The linear model results in a projection that increases by a constant amount for each unit change in the ratio measured (e.g., claim severities). The exponential model produces a constant rate of change in the ratio being measured. Both types of models may be appropriate when measuring increasing trends, though the linear model will eventually project negative values when measuring decreasing trends. Since there is no such thing as a negative frequency or severity in insurance, this is a shortcoming of linear trend models.

The following example shows the result of an exponential curve fit to different durations of calendar year paid frequency, severity, and pure premium data for the 12 months ending each quarter.

6.14 Exponential Loss Trend Example

Year Ending Quarter	Earned Exposure	Closed Claim Count	Paid Losses	Frequency	Annual % Change	Severity	Annual % Change	Pure Premium	Annual % Change
Mar-09	131,911	7,745	$8,220,899	0.0587	--	$ 1,061.45	--	$ 62.32	--
Jun-09	132,700	7,785	$8,381,016	0.0587	--	$ 1,076.56	--	$ 63.16	--
Sep-09	133,602	7,917	$8,594,389	0.0593	--	$ 1,085.56	--	$ 64.33	--
Dec-09	135,079	7,928	$8,705,108	0.0587	--	$ 1,098.02	--	$ 64.44	--
Mar-10	137,384	7,997	$8,816,379	0.0582	-0.9%	$ 1,102.46	3.9%	$ 64.17	3.0%
Jun-10	138,983	8,037	$8,901,163	0.0578	-1.5%	$ 1,107.52	2.9%	$ 64.04	1.4%
Sep-10	140,396	7,939	$8,873,491	0.0565	-4.7%	$ 1,117.71	3.0%	$ 63.20	-1.8%
Dec-10	140,997	7,831	$8,799,730	0.0555	-5.5%	$ 1,123.70	2.3%	$ 62.41	-3.2%
Mar-11	140,378	7,748	$8,736,859	0.0552	-5.2%	$ 1,127.63	2.3%	$ 62.24	-3.0%
Jun-11	139,682	7,719	$8,676,220	0.0553	-4.3%	$ 1,124.01	1.5%	$ 62.11	-3.0%
Sep-11	138,982	7,730	$8,629,925	0.0556	-1.6%	$ 1,116.42	-0.1%	$ 62.09	-1.8%
Dec-11	138,984	7,790	$8,642,835	0.0560	0.9%	$ 1,109.48	-1.3%	$ 62.19	-0.4%
Mar-12	139,155	7,782	$8,602,105	0.0559	1.3%	$ 1,105.38	-2.0%	$ 61.82	-0.7%
Jun-12	139,618	7,741	$8,535,327	0.0554	0.2%	$ 1,102.61	-1.9%	$ 61.13	-1.6%
Sep-12	139,996	7,720	$8,466,272	0.0551	-0.9%	$ 1,096.67	-1.8%	$ 60.48	-2.6%
Dec-12	140,141	7,691	$8,412,159	0.0549	-2.0%	$ 1,093.77	-1.4%	$ 60.03	-3.5%
Mar-13	140,754	7,735	$8,513,679	0.0550	-1.6%	$ 1,100.67	-0.4%	$ 60.49	-2.2%
Jun-13	141,534	7,769	$8,614,224	0.0549	-0.9%	$ 1,108.79	0.6%	$ 60.86	-0.4%
Sep-13	141,800	7,755	$8,702,135	0.0547	-0.7%	$ 1,122.13	2.3%	$ 61.37	1.5%
Dec-13	142,986	7,778	$8,761,588	0.0544	-0.9%	$ 1,126.46	3.0%	$ 61.28	2.1%

Number of Points	Frequency Exponential Fit	Severity Exponential Fit	Pure Premium Exponential Fit
20 point	-1.7%	0.5%	-1.2%
16 point	-1.3%	-0.1%	-1.4%
12 point	-0.7%	-0.2%	-0.9%
8 point	-1.2%	1.2%	-0.1%
6 point	-0.9%	2.5%	1.6%
4 point	-1.5%	3.3%	1.9%

Using statistical methods such as exponential regression also allows for the review of statistical diagnostics. The most commonly used diagnostic is R^2, which is a measure of the reduction of total variance about the mean that is explained by the model.

As demonstrated above, separate exponential models may be fit to the whole of the data and to more recent periods. The actuary ultimately selects the trend(s) to be used to adjust the historical data in the ratemaking experience period to the level expected when the rates will be in effect. If separate frequency and severity trends are selected, these selected trends are combined to a single pure premium trend. For example, a -1% selected annual frequency trend and a +2% selected annual severity trend combine to produce a +1% (= (1.0 - 1%) x (1.0 + 2%) - 1.0) selected annual pure premium trend.

Table 6.14 is an example of using an exponential fit. When using a linear trend approach, the actuary calculates the difference in the frequency, severity, and pure premium rather than the percentage difference. The linear fit produces a constant amount of change (rather than a percentage change). For example, the dollar change based on the 20-point linear fit on the pure premium data is -$0.75.

Catastrophe losses are normally excluded from the loss trend analysis data. If unusually large individual losses are present, the actuary may choose to remove or adjust the extraordinary losses or select loss severity trends based on basic limits loss data. If catastrophe or large losses cannot be identified, the use of 12-month rolling averages is disadvantageous since one event will transfer to multiple data points.[22] In the case of a catastrophe, the frequency and severity will each likely increase significantly when the catastrophe claims enter the trend data and decrease significantly when the catastrophe claims no longer exist in the data. Extraordinary losses tend to be singular claims, so they generally only impact severity. If the data cannot be directly adjusted, the actuary can judgmentally account for the catastrophes or extraordinary losses when making the loss trend selections.

Changes in benefit levels can also affect trend analyses. For example, if a law change increases the expected payments by 10% for all claims occurring after a certain date, it will appear as a positive severity trend until all claims are being settled under the new law. The actuary may attempt to restate the historical trend data to the benefit levels that will be in effect during the period the rates will be in effect. If the data is not restated, then the actuary should consider the impact of the benefit changes during the trend selection process. If the historical data to which selected loss trends will be applied is restated to reflect the new benefit level, then either data adjusted for benefit level should be used for the trend analysis, or the trend analysis must remove the impact of the benefit level change. The pricing actuary must take care not to "double count" the benefit level change in the projected losses.

The ratemaking actuary should use judgment in deciding whether the historical data is overly volatile or otherwise inappropriate for trending purposes. For example, the data may be too sparse or reflect non-recurring events that cannot be appropriately adjusted. Alternatively, the statistical goodness of fit of the trending procedure may be called into question. One option is to supplement the loss trend data with multi-state, countrywide, or industry trend data and consider weighting the results. Alternatively, the actuary may consider non-insurance indices, if available. For example, the medical component of the CPI (Consumer Price Index) may be relevant when selecting severity trends for insurance products related to medical expense coverage. The U.S. Bureau of Labor Statistics also publishes average weekly wage changes by state, which can be useful when selecting trends for U.S. workers compensation indemnity losses.

[22] If catastrophe claims are paid in the first quarter of 2011, then they will affect the 12-month calendar year loss trend data for the 12 months ending the first, second, third, and fourth quarters of 2011. If the catastrophe claims are paid out over several quarters, then it will extend the impact even further.

In addition to regression models, more sophisticated techniques such as econometric models and generalized linear models may be employed for quantifying loss trends. A more detailed discussion of these methods is beyond the scope of this text.

Loss Trend Periods

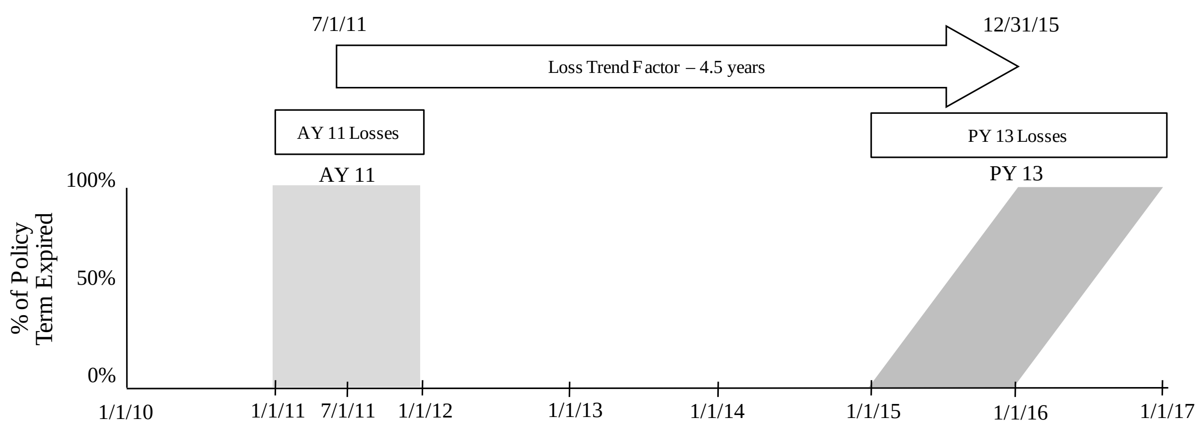
Selecting the loss trend(s) is only the first step of the trending process. Similar to premium trends, the actuary must calculate the applicable **loss trend period**. This is the period of time from the average loss occurrence date of each experience period (typically a calendar-accident year) to the average loss occurrence date for the period in which the rates will be in effect (a policy year or years). This latter period is referred to as the forecast period. The loss trend period depends on both the term of the policy and the expected duration for the new rates, typically chosen as one year.

For example, assume the following:

- The losses to be trended are from Accident Year 2011.
- The company writes annual policies.
- The proposed effective date is January 1, 2015.
- The length of time the rates are expected to be in effect is one year.

The average loss occurrence date of Calendar-Accident Year 2011 (sometimes called the "trend from" date) is assumed to be July 1, 2011. This is the midpoint of the calendar-accident year period for which the annual policies provide coverage. The average loss occurrence date for the policy year period in which rates will be in effect (sometimes called the "trend to" date) is assumed to be December 31, 2015. This is because the policies will be written between January 1, 2015, and December 31, 2015, but the coverage for these policies will extend until December 31, 2016. The midpoint of that two-year time period is December 31, 2015. Therefore, the loss trend period for Calendar-Accident Year 2011 is 4.5 years. The following picture displays this.

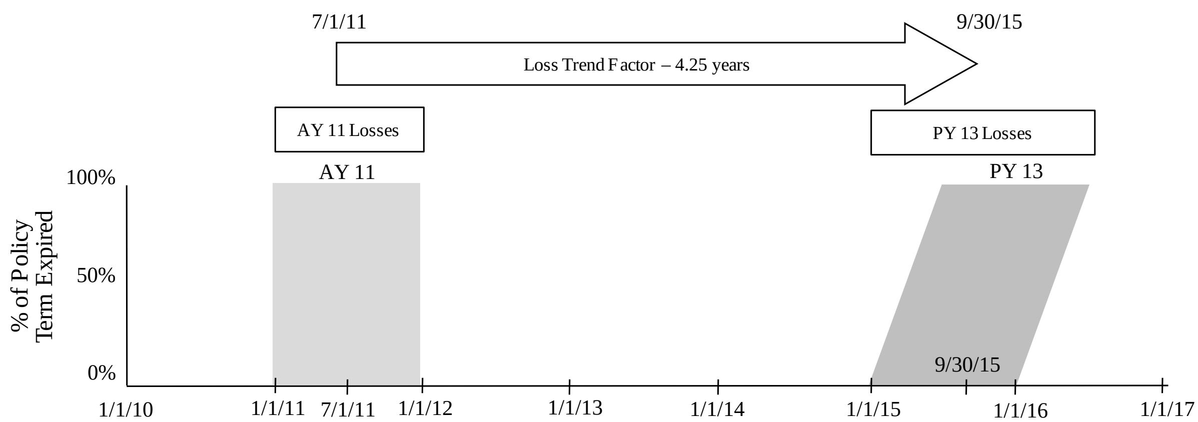
6.15 Loss Trend Period for 12-month Policy Term



The annual pure premium trend selected above, +1%, is applied to Calendar-Accident Year 2011 losses by multiplying the historical losses by $(1.01)^{4.5}$, which is referred to as a loss trend factor.

If the policy term were semi-annual rather than annual, the "trend from" date would not change, but the "trend to" date would be different. Coverage for policies written between January 1, 2015 and December 31, 2015 would extend over an 18-month period, of which the midpoint would be 9 months (i.e., September 30, 2015). The trend length would be 4.25 years, as displayed below.

6.16 Loss Trend Period for 6-month Policy Term



If the historical data were aggregated by policy year, the average loss occurrence date with respect to an annual policy term would be one year after the start of the policy year, as policies are in effect over a 24-month period. The "trend to" date is the average loss occurrence date for the policy year period in which rates will be in effect. Therefore, the trend period for Policy Year 2011 annual term policies is 4 years (January 1, 2012 to December 31, 2015), as shown in Exhibit 6.17. The Policy Year 2011 trend factor , which would be applied to Policy Year 2011 losses, is 1.0406 ($= 1.01^{4.0}$).

6.17 Loss Trend Period for 12-month Policy Term and PY experience period

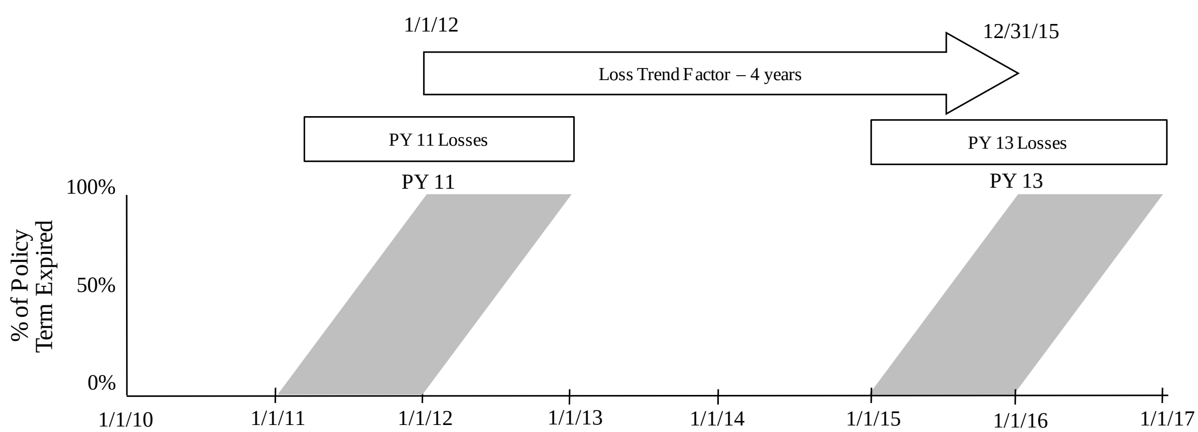
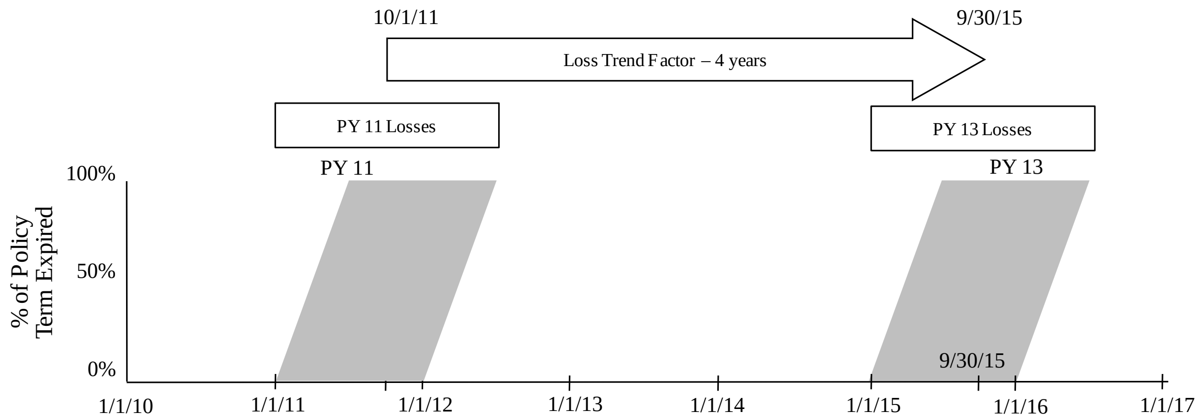


Exhibit 6.18 shows the same policy year scenario but with semi-annual policies. Both the "trend from" and "trend to" dates are three months earlier than the annual policy scenario since the average occurrence date for semi-annual policies is nine months after the start of the policy year. The trend length is still 4 years.

6.18 Loss Trend Period for 6-month Policy Term and PY experience period

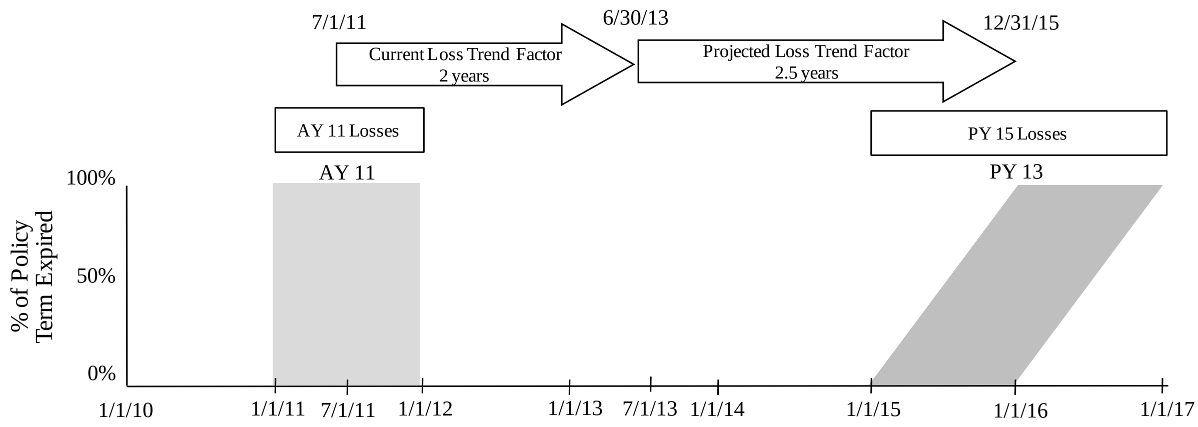


If the trend selection is based on a linear trend, then the selected trend is a constant amount rather than a percentage. In this case, the projected dollar change is calculated by multiplying the selected annual trend by the length of the trend period. For example, assume the selected annual pure premium linear trend is $1.00 per year, then the dollar increase due to 4 years of trend is $4.00 (= $1.00 x 4.0).

In some circumstances, the actuary may choose to undertake a two-step trending process. This technique is beneficial when the actuary believes that the loss trend in the historical experience period and the expected trend for the forecast period are not identical. For example, some lines of business may require several historical years be used when projecting losses for ratemaking purposes. If the trend during that historical period has been significantly different from what is expected to occur in the future, it may make sense to adjust the historical data to current levels accordingly, but to apply a different trend into the forecast period to reflect what is expected to occur in the future. Legislative changes in the trend data are a particular example when the two-step trending process may be appropriate if the trend exhibited in the historical period is clearly different from that expected in the future.

In the exponential trend data shown in Table 6.14, one can see that the historical severity trend exhibits a different pattern in more recent periods than in earlier years. First, the losses in the experience period are trended from the average accident date in the experience period to the average accident date of the last data point in the trend data. For example, the average loss occurrence date of Calendar-Accident Year 2011 (the "trend from" date) is assumed to be July 1, 2011. If the last data point in the loss trend data is the twelve months ending fourth quarter 2013, the average accident date of that period (the "trend to" date) is June 30, 2013. The current trend period is therefore 2 years. If the selected current trend is -1%, the factor to adjust Calendar-Accident Year 2011 losses to the average accident date of the latest data point is 0.98 (= $(1.0 - 1\%)^2$). Second, these trended losses are projected from the average accident date of the latest data point (the "project from" date of June 30, 2013) to the average loss occurrence date for the forecast period (assuming annual policies, the "project to" date of December 31, 2015). The length of this projection period is 2.5 years. If the loss projection trend selected is 2%, losses trended to current level are further adjusted by a factor of 1.05 (= $(1.0 + 2\%)^{2.5}$). The following picture displays this.

6.19 Two-Step Trend Periods for 12-month Policy



If calendar year data is used to measure loss trend, one of the underlying assumptions is that the book of business is not significantly increasing or decreasing in size. This assumption sometimes does not hold in reality and therefore using calendar year data to measure trend can cause over or underestimation of the trend. The problem with calendar year data is that claims (or losses) in any calendar year may have come from older accident years, yet they are matched to the most recent calendar year exposures (or claims). A change in exposure levels changes the distribution of each calendar year's claims by accident year.

The solution is to attempt to match the risk with the appropriate exposure. One alternative mentioned previously is to use econometric techniques or generalized linear models to measure trend. This will absorb changes in the size of the portfolio as well as changes in the mix of business. Another approach is to measure the trend using accident year data (in lieu of calendar year data). This is often done in commercial lines trend analysis even when the portfolio size is not changing dramatically—merely because the calendar year results are unreliable for trend purposes. The accident year losses (or claim counts) need to be developed to ultimate before measuring the trend, which introduces some subjectivity into the trend analysis.

Another alternative is to analyze the trend in incremental calendar year frequencies or severities. This involves splitting each calendar year's claim counts (or paid losses) by accident year and matching them to the exposures (or claim counts) that produced them. For example, assume Calendar Year 2010 has paid losses on claims from Accident Years 2010, 2009, and 2008. The Calendar Year 2010 frequency is the sum of all paid claim counts in Calendar Year 2010 divided by Calendar Year 2010 exposures. The alternative approach sums three incremental Calendar Year 2010 frequencies:

- Calendar Year 2010 paid claim counts from Accident Year 2010 divided by Calendar Year 2010 exposures
- Calendar Year 2010 paid claim counts from Accident Year 2009 divided by Calendar Year 2009 exposures
- Calendar Year 2010 paid claim counts from Accident Year 2008 divided by Calendar Year 2008 exposures

If the company's exposures decreased substantially during the period of 2008-2010, the company will be settling claims in 2010 produced from a larger portfolio (Accident Years 2008 and 2009) but comparing them to the smaller book than the company has today (Calendar Year 2010 exposures).

The alternative method more properly matches the older claim counts to the older exposures; moreover this method would be valid whether the portfolio is changing or not. More detail on this alternative approach to trending can be found in Chris Styrsky's paper "The Effect of Changing Exposure Levels on Calendar Year Loss Trends" (Styrsky, 2005).

Leveraged Effect of Limits on Severity Trend

When the loss experience being analyzed is subject to the application of limits, it is important that the leveraged effect of those limits on the severity trend be considered. Basic limits ratemaking was discussed in an earlier section. Recall basic limits losses are losses that have been censored at a pre-defined limit referred to as a "basic limit." Total limits losses are losses that are uncensored, and excess limits are the portion of the losses that exceed the basic limit (or the difference between total limits and basic limits losses). It is important to understand that severity trend affects each of these differently.

Consider the following simple example in which every total limits loss is subject to a 10% severity trend.

6.20 Effect of Limits on Severity Trend

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				Trended Losses					
				Total Limits		Capped @ $25,000		Excess Losses	
Claim Number	Total Limits Loss	Losses Capped @ $ 25,000	Excess Losses	Loss	Trend	Loss	Trend	Loss	Trend
1	$ 10,000	$ 10,000	$ -	$ 11,000	10.0%	$ 11,000	10.0%	$ -	N/A
2	$ 15,000	$ 15,000	$ -	$ 16,500	10.0%	$ 16,500	10.0%	$ -	N/A
3	$ 24,000	$ 24,000	$ -	$ 26,400	10.0%	$ 25,000	4.2%	$ 1,400	N/A
4	$ 30,000	$ 25,000	$ 5,000	$ 33,000	10.0%	$ 25,000	0.0%	$ 8,000	60.0%
5	$ 50,000	$ 25,000	$ 25,000	$ 55,000	10.0%	$ 25,000	0.0%	$ 30,000	20.0%
Total	$ 129,000	$ 99,000	$ 30,000	$ 141,900	10.0%	$ 102,500	3.5%	$ 39,400	31.3%

(2)= min[(1) , $25,000]
(3)= (1) - (2)
(4)= (1) x 1.10
(5)= (4) / (1) - 1.0
(6)= min[(4) , $25,000]
(7)= (6) / (2) - 1.0
(8)= (4) - (6)
(9)= (8) / (3) -1.0

As can be seen in the table above, the 10% trend in total limits losses affects basic limits losses and excess losses differently. On average, the 10% total limits trend is dampened to 3.5% when considering the basic limits losses. The two smallest losses (Claims 1 and 2) are significantly below the limit of $25,000 and were still under $25,000 even after the 10% increase. Claim 3 was below $25,000 before trend was applied, but the trend pushes the total amount of that claim above the basic limit. Consequently, only 4.2% of the trend increase is realized in the basic limit layer. Claims 4 and 5 were already in excess of $25,000, so the amount of loss under the limit is the same before and after the trend.

In contrast to the basic limits, the magnitude of the positive trend on excess losses is greater than the total limits trend. Because Claims 1 and 2 are significantly below the limit, they do not exceed the limit even after the 10% increase and do not impact the trend in the excess layer. Claim 3 was below the limit prior to the application of trend, but pierced into the excess layer after the trend. Claims 4 and 5 were already higher than the limit; consequently, the entire increase in losses associated with these claims is realized in the excess losses trend.

Table 6.21 highlights the differences in trend for each layer:

6.21 Effect of Limits on Increasing Severity Trend

Initial Loss Size	Basic Limits	Total Losses	Excess Losses
$\text{Loss} < \frac{\text{Limit}}{1.0 + \text{Trend}}$	Trend	Trend	Undefined
$\frac{\text{Limit}}{1.0 + \text{Trend}} \leq \text{Loss} < \text{Limit}$	$\frac{\text{Limit}}{\text{Loss}} - 1.0$	Trend	Undefined
$\text{Limit} \leq \text{Loss}$	0%	Trend	$\frac{[\text{Loss} \times (1.0 + \text{Trend})] - \text{Limit}}{\text{Loss} - \text{Limit}}$

In the case of positive severity trend this means:

$$\text{Basic Limits Trend} \leq \text{Total Limits Trend} \leq \text{Excess Losses Trend.}$$

In the case of negative severity trends, the relationship becomes:

$$\text{Excess Losses Trend} \leq \text{Total Limits Trend} \leq \text{Basic Limits Trend.}$$

Where severity trends have been analyzed based on total limits loss data, the resulting indicated severity trend must be adjusted before it is applied to basic limits losses for ratemaking purposes. Alternatively, some actuaries prefer to use basic limits data in analyzing severity trend.

Note that deductibles also have a leveraging effect on severity trend. The mathematics is analogous to excess losses except that the censoring is done below the deductible rather than above the limit.

Coordinating Exposure, Premium, and Loss Trends

Trends in exposure and premium were discussed in prior chapters. Whether examining loss ratios or pure premiums to determine the rate level indication, it is important to make sure that all components of the formula are trended consistently. This can be a little more challenging for lines of business with inflation-sensitive exposure bases (e.g., payroll in workers compensation, gross revenue in commercial general liability, etc.).

When deriving a pure premium rate level indication, pure premiums are projected into the forecast period. Three types of trends that are considered in that projection are changes in the likelihood of a claim happening, changes in the average cost of claims, and changes in the level of exposure.

When the company's internal frequency and severity trend data is used as the basis of the loss trend analysis, the changes in frequency (i.e., number of claims divided by exposure) account for the net effect of the change in the probability of having a claim and the change in exposure. This also holds when examining pure premium data.

When using inflation-sensitive exposure bases, the inflationary pressure on the exposure can mask part or all of the change in the likelihood of claims occurring. This makes it difficult to understand how the loss components are changing over time. In order to remove the effect of the changing exposure, the actuary may choose to examine historical frequencies (or pure premiums) that have been adjusted for exposure trend (i.e., the denominator has been adjusted by the exposure trend). This frequency trend adjusted for changes in exposure is combined with the severity trend to form a pure premium trend, which is then applied to historical losses (which have been or will be adjusted for loss development, benefit changes, extraordinary loss provisions, etc.) to project them into the period for which rates will be in effect. To maintain consistency, this projected loss measure needs to be compared to exposures that have been projected to future levels using the selected exposure trend.

When deriving a loss ratio indication, it is also important to maintain consistency among the components. Some actuaries examine patterns in historical adjusted loss ratios. This is the ratio of losses adjusted for development, benefit changes, and extraordinary losses compared to premium adjusted to current rate level. This trend in this context is sometimes referred to as a "net" trend, though use of the word "net" may be confusing as it is generally used to imply net of reinsurance. Based on the historical pattern in the adjusted loss ratios, the actuary selects a loss ratio trend to adjust the historical loss ratios to the projected policy period. One shortcoming of this approach is that trends in adjusted loss ratios over time may not be stable, and it can be more difficult for the actuary to understand what may be driving the results.

Similar to the discussion above about trending within the pure premium approach, it may be preferable to examine the individual components of the loss ratio statistic. In other words, the actuary examines changes in each component (i.e., frequency, severity, and average premium) separately and adjusts each component accordingly. Assuming the historical exposures are used to calculate the frequency (or pure premium) and average premium used in the trend analysis, each component will be adjusted consistently. Looking at patterns in historical frequency, severity, and exposure separately provides a better understanding of how each individual statistic is changing and therefore how the entire loss ratio statistic is changing.

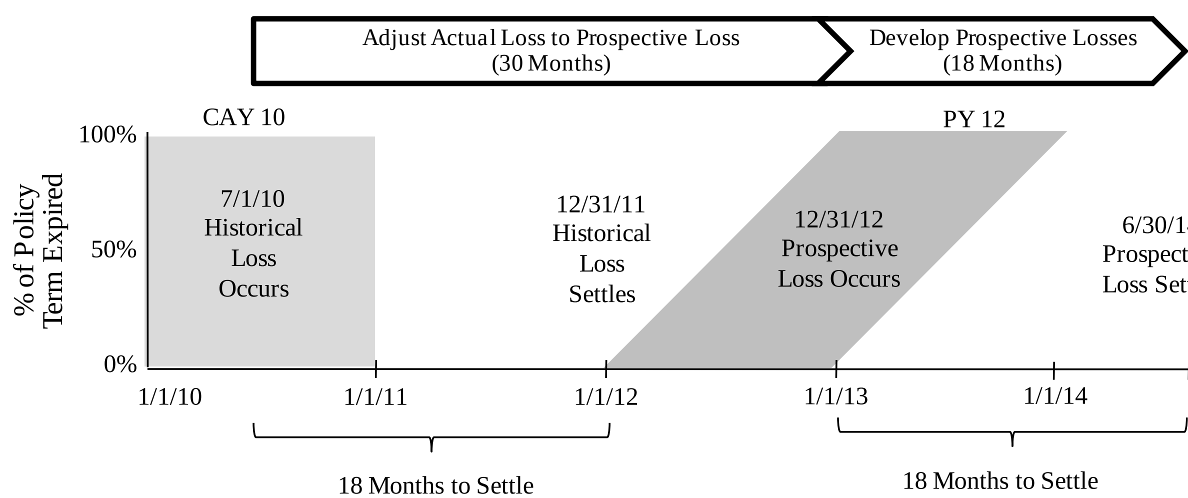
Insurers may choose to use external indices, rather than internal trend data, to select loss trends. For example, a workers compensation insurer may use an external study as the basis to estimate the expected increase in utilization and cost of medical procedures. When this is done, the loss trend selection does not implicitly account for any expected change in the insurer's premium or exposure due to an inflation-sensitive exposure base. Consequently, the exposure or premium needs to be adjusted to reflect any expected change in exposure.

Appendices A-F highlight some of the different approaches. The auto and homeowners examples do not have inflation-sensitive exposure bases and use internal trend data, so the coordination is straightforward. However, the homeowners example does include a projection of the amount of insurance years, which is necessary for the projection of the non-modeled catastrophe loading. The medical malpractice loss ratio example includes a net trend approach. Trend selections are made using internal data. The "frequency" is actually the number of claims divided by the premium, so the frequency selection accounts for pure frequency trend as well as premium trend. The workers compensation example separately applies loss and exposure trend.

Overlap Fallacy: Loss Development and Loss Trend

It may seem that trending and developing losses results in overlapping adjustments; however, this is not the case. Recall that losses in the historical experience period occurred months or years prior to the period the rates will be in effect and are not normally fully developed at the time of the analysis. Trending procedures restate losses that occurred in the past to the level expected for similar losses that will occur during the future period in consideration of inflation and other factors. Loss development procedures bring the immature losses to their expected ultimate level. It is true that loss development incorporates inflationary pressures that cause payments for reported claims to increase in the time after reporting, but this does not prove an overlap either. The timeline below provides a graphical illustration of how losses are trended and developed.

6.22 Overlap Fallacy



In this example, the historical experience period is Calendar-Accident Year 2010. The average date of claim occurrence is July 1, 2010. Assume it is typical for claims to settle within 18 months, so this "average claim" will settle on December 31, 2011. The projection period is the policy year beginning January 1, 2012 (i.e., rates are expected to be in effect for annual policies written from January 1, 2012, through December 31, 2012). The average hypothetical claim in the projected period will occur on

January 1, 2013, and settle 18 months later on June 30, 2014 (i.e., consistent with the settlement lag of 18 months). Trend adjusts the average historical claim from the loss cost level that exists on July 1, 2010, to the loss cost level expected on January 1, 2013; while trended to the new cost level, the adjusted claim is still not fully developed. Development adjusts the trended, undeveloped claim to the ultimate level, which is expected to be achieved by June 30, 2014.

In conclusion, the goal is to project the expected settlement value of the average historical claim (which occurred on July 1, 2010) as if it were to occur on December 31, 2012, and be settled on June 30, 2014. This duration of 48 months represents the 30 months of trend to adjust the cost level to that anticipated during the forecast period and the 18 months of development to project this trended value to its ultimate settlement value.

LOSS ADJUSTMENT EXPENSES

Loss adjustment expenses (LAE) are all costs incurred by a company during the claim settlement process. As such, they are more appropriately placed with a discussion of losses than with other insurance company expenses.

Claim adjusters' fees, claim department overhead, and legal defense costs are examples of LAE. Traditionally, LAE have been divided into two categories, allocated and unallocated loss adjustment expenses. **Allocated loss adjustment expenses (ALAE)** are those costs that can easily be related to individual claims. Legal fees to defend against a specific claim or costs incurred by a claim adjuster assigned to one claim are ALAE. **Unallocated loss adjustment expenses (ULAE)** are those that are more difficult to assign to particular claims, such as claim department salaries.

In 1998, the insurance industry introduced new LAE definitions in an attempt to improve financial reporting consistency between companies in the US. Instead of categorizing loss adjustment expenses by allocated or unallocated for financial reporting purposes, costs are now split into **defense cost and containment (DCC) expenses** and **adjusting and other (A&O) expenses**. DCC expenses include costs incurred in defending claims, including expert witness fees and other legal fees. A&O include all other expenses. Prior to the switch, companies with in-house attorneys sometimes coded legal expenses as ULAE, while companies using outside legal counsel coded these expenses as ALAE. This historic difference made comparing operations metrics across companies difficult. The new standardization of the definitions makes these comparisons more meaningful. Despite the change in U.S. financial reporting definitions, this text will refer to the subdivisions of ALAE and ULAE, which are more commonly used in ratemaking.

In general, ALAE or DCC vary by the dollar amount of each claim, while ULAE or A&O vary by the number of claims reported. For ratemaking purposes, ALAE are often included with losses. This includes both the losses used for projection as well as the losses used in detecting patterns of loss development and trend. Some pricing actuaries, most notably in commercial lines, may elect to study development and trend patterns separately for loss and ALAE. This is done if ALAE are significantly high for the given line of business or in order to detect any changes in ALAE patterns. It is also important for the actuary to understand whether ALAE are subject to the policy limits or not. This does not necessarily affect the treatment of ALAE in a ratemaking context, but it emphasizes the need to understand whether the ALAE data retrieved is the entire ALAE or only the portion included within the policy limits.

On the other hand, ULAE are more difficult to incorporate into the loss projection process. At any time a claims department may be working on settling claims that arise from events occurring during many historical time periods and pertaining to many lines of business. Because of this, companies need to allocate ULAE to losses in a sensible way.

A simple method for allocating ULAE is based on the assumption that ULAE expenditures track with loss and ALAE dollars consistently over time, both in terms of rate of payment and in proportion to the amount of losses paid. The procedure involves calculating the ratio of calendar year paid ULAE to calendar year paid loss plus ALAE over several years (e.g., three years or longer, depending on the line of business). This ratio (see Table 6.23) is then applied to each year's reported loss plus ALAE to incorporate ULAE. The ratio is generally calculated on losses that have not been adjusted for trend or development as this data is readily available for other financial reporting. This inherently assumes that ULAE trend and develop at the same rate as loss plus ALAE. The resulting ratio of ULAE to loss plus ALAE is then applied to loss plus ALAE that has been adjusted for extraordinary events, development, and trend. For lines of business where ALAE is not substantial (e.g. homeowners), this adjustment may be done for ALAE and ULAE combined.

6.23 ULAE Ratio

Calendar Year	(1) Paid Loss and ALAE	(2) Paid ULAE	(3) ULAE Ratio
2008	$ 913,467	$ 144,026	15.8%
2009	$ 1,068,918	$ 154,170	14.4%
2010	$ 1,234,240	$ 185,968	15.1%
Total	$ 3,216,625	$ 484,164	15.1%
		(4) ULAE Factor	1.151

(3) = (2) / (1)
(4) = 1.0 + (Tot3)

Catastrophic events can cause extraordinary loss adjustment expenses. For example, in the event of a major catastrophe, a company may have to set up temporary offices in the catastrophe area. To the extent that those costs are significant and irregular, the historical ratio will be distorted. Thus, catastrophe loss adjustment expenses are generally excluded from the standard ULAE analysis and are determined as part of the catastrophe provision.

The method described above is a dollar-based allocation method. Actuaries may also consider count-based allocation methods that assume the same kinds of transactions cost the same amount regardless of the dollar amount of the claim, and that there is a cost associated with a claim remaining over time. More detail on such methods is beyond the scope of this text.

Another ULAE allocation approach is to study how claim adjusters spend their time—working on what types of claims, what types of claim activities, lines of business, etc. This may not be an easy undertaking, but it does bring more confidence that the ULAE dollars are being allocated for ratemaking purposes according to how they are being spent in practice. Before proceeding, the actuary should consider whether the cost of the study is worth the additional accuracy gained as the effort can be very time-consuming.

SUMMARY

Losses and LAE usually represent the largest component of insurance costs and require the most attention from the pricing actuary. The pricing actuary's role is to estimate expected losses and LAE for a future policy period. This is typically done based on aggregated historical data with a series of adjustments. Losses need to be adjusted for non-recurring extreme events such as shock losses, catastrophes, and benefit changes. They also need to be adjusted to reflect ultimate settlement values and future cost levels. These latter adjustments are typically calculated based on examination of historical patterns of loss development and trend. Finally, the actuary needs to incorporate any loss adjustment expenses that will be paid to investigate and settle claims.

Examples of these loss and LAE adjustments and how they are incorporated in overall rate level analyses for various lines of business are included in Appendices A-D.

KEY CONCEPTS IN CHAPTER 6

1. Loss definitions
    a. Paid loss
    b. Case reserves
    c. Reported loss
    d. Ultimate loss

2. Loss aggregation methods
    a. Calendar year
    b. Calendar-accident year
    c. Policy year
    d. Report year

3. Common ratios involving losses
    a. Frequency
    b. Severity
    c. Pure premium
    d. Loss ratio

4. Extraordinary losses

5. Catastrophe losses
    a. Non-modeled catastrophes
    a. Modeled catastrophes

6. Reinsurance recoveries and costs

7. Changes in coverage or benefit levels

8. Loss development

9. Loss trend
    a. Loss trend selection
    b. Loss trend period
    c. Leveraging effect of limits on severity trend
    d. Coordinating exposure, premium, and loss trends

10. Overlap fallacy

11. Loss adjustment expenses (LAE)
    a. Definitions of allocated and unallocated LAE
    b. Treatment of ALAE
    c. Allocation of ULAE

CHAPTER 7: OTHER EXPENSES AND PROFIT

As stated in Chapter 1, the fundamental insurance equation is as follows:

$$\text{Premium} = \text{Losses} + \text{LAE} + \text{UW Expenses} + \text{UW Profit}.$$

The role of a pricing actuary is to estimate each of these components for the period during which the proposed rates will be in effect. The preceding chapters provided techniques for estimating the projected premium and the projected losses and LAE. This chapter addresses:

- How to derive projected underwriting expense ratios
- How to incorporate the cost of reinsurance in a ratemaking analysis
- How to incorporate an underwriting profit provision in rates

SIMPLE EXAMPLE

The following simple example illustrates how expenses and profit are incorporated within the fundamental insurance equation and in the ratemaking process. Assume the following:

- The average expected loss and LAE ($\bar{L} + \bar{E}_L$) for each policy is $180.
- Each time the company writes a policy, the company incurs $20 in expenses ($\bar{E}_F$) for costs associated with printing and data entry, etc.
- 15% of each dollar of premium collected covers expenses that vary with the amount of premium, (*V*), such as premium taxes.
- Company management has determined that the target profit provision (Q_T) should be 5% of premium.

If the rates are appropriate, the premium collected will be equivalent to the sum of the expected losses, LAE, underwriting (UW) expenses (both fixed and variable), and the target underwriting profit. Using the notation outlined in the Foreword (p. vi), this can be written as:

$$\text{Premium} = \text{Losses} + \text{LAE} + \text{UW Expenses} + \text{UW Profit}.$$

$$P = L + E_L + (E_F + V \times P) + Q_T \times P$$

$$P - (V + Q_T) \times P = L + E_L + E_F$$

$$P = \frac{[L + E_L + E_F]}{[1.0 - V - Q_T]}$$

$$\bar{P} = \frac{[L + E_L + E_F]/X}{[1.0 - V - Q_T]} = \frac{[\bar{L} + \bar{E}_L + \bar{E}_F]}{[1.0 - V - Q_T]}.$$

Substituting the values from the simple example into the formula yields the following premium:

$$\bar{P} = \frac{[\bar{L} + \bar{E}_L + \bar{E}_F]}{[1.0 - V - Q_T]} = \frac{[\$180 + \$20]}{[1.0 - 0.15 - 0.05]} = \$250.$$

In other words, the company should charge $250, which is made up of $180 of expected losses and loss adjustment expenses, $20 of fixed expenses, $37.50 (= 15% x $250) of variable expenses, and $12.50 (= 5% x $250) for the target UW profit. The focus of this chapter is determining the fixed expense provision (i.e., the $20), the variable expense provision (i.e., 15%), and the profit provision (i.e., 5%).

UNDERWRITING EXPENSE CATEGORIES

Companies incur expenses in the acquisition and servicing of policies. These expenses are generally referred to as underwriting expenses (or operational and administrative expenses). Companies usually classify these expenses into the following four categories:

- Commissions and brokerage
- Other acquisition
- Taxes, licenses, and fees
- General

Commissions and brokerage are amounts paid to agents or brokers as compensation for generating business. Typically, these amounts are paid as a percentage of premium written. Commission rates may vary between new and renewal business. In addition, contingent commissions vary the commission based on the quality (e.g., a loss ratio) or amount of business written (e.g., predetermined volume goals).

Other acquisition costs are expenses that are paid to acquire business other than commissions and brokerage expenses. Costs associated with media advertisements, mailings to prospective insureds, and salaries of sales employees who do not work on a commission basis are included in this category.

Taxes, licenses, and fees include all taxes and miscellaneous fees due from the insurer excluding federal income taxes. Premium taxes and licensing fees are examples of items included in this category.

General expenses include the remaining expenses associated with insurance operations and any other miscellaneous costs, excluding investment income expenses (these expenses are typically reflected as an offset to investment income and further discussion is beyond the scope of this text). For example, the general expense category includes overhead associated with the insurer's home office (e.g., building maintenance) and salaries of certain employees (e.g., actuaries).

Actuaries sometimes estimate the underwriting expense provision for ratemaking by further dividing underwriting expenses into two groups: fixed and variable. Fixed expenses are assumed to be the same for each risk, regardless of the size of the premium (i.e., the expense is a constant dollar amount for each risk or policy).[23] Typically, overhead costs associated with the home office are considered a fixed

[23] It is likely that some of these expenses do bear some relationship to risk and may vary with premium, especially in extreme circumstances. Activity-based cost studies may be able to verify the true relationship, and appropriate adjustments can be made.

expense. Variable expenses vary directly with premium; in other words, the expense is a constant percentage of the premium. Premium taxes and commissions are two examples of variable expenses. In the past, no distinction was recognized between fixed and variable expenses, and actuaries estimated all underwriting expenses in the same way. More recently, techniques have been developed to estimate fixed and variable expenses separately in cases where both types of expenses are material.

The magnitude and distribution of underwriting expenses vary significantly for different lines of business. For example, commissions tend to be much higher in lines that require a comprehensive inspection at the onset of the policy (e.g., large commercial property) than for lines that do not involve such activity (e.g., personal automobile). The expenses can even vary significantly by company within a given line of business. For example, a national direct writer may incur significant other acquisition costs for advertising. In contrast, an agency-based company may rely more heavily on the agents to generate new business; consequently, the other acquisition costs will be lower, but this will be at least partially offset by higher commission expenses.

The next sections outline three different procedures used to derive expense provisions for ratemaking:

- All Variable Expense Method
- Premium-based Projection Method
- Exposure/Policy-based Projection Method

ALL VARIABLE EXPENSE METHOD

In the past, actuaries used the All Variable Expense Method, which does not differentiate between fixed and variable underwriting expenses and treats all expenses as variable (i.e., all expenses are assumed to be a constant percentage of premium). More specifically, this method assumes that expense ratios during the projected period will be consistent with the historical expense ratios (i.e., all historical underwriting expenses divided by historical premium). This approach is still used when pricing insurance products for which the total underwriting expenses are dominated by variable expenses (i.e., many commercial lines products). Table 7.1 shows an example of this method for deriving the other acquisition expense provision of a commercial general liability insurer.

7.1 Other Acquisition Provisions Using All Variable Expense Method

	2013	2014	2015	3-Year Average	Selected
a Countrywide Expenses	$72,009	$104,707	$142,072		
b Countrywide Written Premium	$1,532,091	$1,981,109	$2,801,416		
c Variable Expense % [(a)/(b)]	4.7%	5.3%	5.1%	5.0%	5.0%

To derive the expense ratio, the historical calendar year expenses are divided by either calendar year written or earned premium during that same historical experience period. The choice of whether to use written or earned premium depends on whether the expenses under consideration are generally incurred at the onset of the policy (e.g., commissions) or throughout the policy (e.g., building maintenance). Written premium is used when expenses are incurred at the inception of the policy as it reflects the premium at the onset of the policy. Earned premium is used when expenses are assumed to be incurred throughout the policy as it reflects the gradual payment of expenses that can be proportional to the earning of premium over the policy term. As acquisition expenses are generally incurred at the onset of the policy, the example displayed is based on a ratio to written premium. The choice of written or earned premium will have relatively little impact if a company's volume of business is not changing materially (since written premium will be approximately equal to earned premium). However, if a company is growing (or shrinking) significantly, written premium will be proportionately higher (or lower) than earned premium. Similarly, during a period of growth (or decline) the acquisition costs will be higher (or lower) than during a period of stable volume. Use of an appropriate premium measure provides a better match to the types of expenses incurred during the historical period.

Each year U.S. insurance companies must produce an Annual Statement and Insurance Expense Exhibit (IEE). These documents contain a significant amount of accounting data, including historical expense and premium data. However, this data may not be available in the finest level of detail necessary for ratemaking purposes. For example, the homeowners data includes renters and mobile homes data, and as a result, may not be appropriate for deriving expense provisions specifically for homeowners policies. Ideally, the actuary will have access to the source expense data at the level of detail required for each product or subline priced. Of course, the actuary should always weigh the cost of obtaining such data against the additional accuracy gained.

Typically, the choice to use countrywide or state data varies by type of expense. Other acquisition costs and general expenses are usually assumed to be uniform across all locations, so countrywide figures found in the IEE are used to calculate these ratios. The data used to derive commissions and brokerage expense ratios varies from carrier to carrier. Some carriers use state-specific data and some use countrywide figures, depending on whether the company's commission plans vary by location. Taxes, licenses, and fees vary by state and sometimes by territory within a state; therefore, the expense ratios for this category are typically based on state data from the Annual Statement.

The following table summarizes the type of data used in the calculation of the historical expense ratio for each expense category:

7.2 Data Summization for All Variable Expense Method

Expense	Data Used	Divided By
General Expense	Countrywide	Earned Premium
Other Acquisition	Countrywide	Written Premium
Commissions and Brokerage	Countrywide/State	Written Premium
Taxes, Licenses, and Fees	State	Written Premium

The actuary calculates the historical expense ratios for each category and year. Typically, the actuary will also calculate a multi-year average; the multi-year average may be a straight average or a weighted average (a straight average is used in Table 7.1). Generally, the actuary selects a ratio for each expense type based on either the latest year's ratio or a multi-year average of ratios balanced with management input, prior expense loads, and judgment. There are several additional considerations that may affect the selection. Because the ratemaking process is a projection of future costs, the actuary should select an expense ratio consistent with what is expected in the future, and this may differ from a historical ratio. Examples of this are as follows:

- If the commission structure is changing, the actuary should use the expected commission percentage, not the historical percentage.

- If productivity gains led to a significant reduction in staffing levels during the latest historical experience period, then the selected ratios should be based on the expected expenses after the reduction rather than the all-year average.
- A growing portfolio can cause expense ratios to decrease (since the volume will likely increase faster than expenses); however, if the company plans to open a new call center to handle even greater planned growth, consideration should be given to the fact that fixed costs will increase in the short-term until the planned growth is achieved.

If there were non-recurring expense items during the historical period, the actuary should examine the materiality and nature of the expense to determine how to best incorporate the expense in the rates—if at all. If the aggregate dollars spent are consistent with dollars expected to be spent on similar non-recurring projects in the future, then the expense ratios should be similar and no adjustment is warranted. However, if the expense item represents an extraordinary expense, then the actuary must decide to what extent it should be reflected in the rates. For example, assume the extraordinary expense is from a major project to improve the automated policy issuance process. The actuary may decide to reflect the expense in the rates. Assuming the new system will be used for a significant length of time, it may be appropriate to dampen the impact of the item by spreading the expense over a period of several years. On the other hand, if the actuary decides not to reflect the expense in the rates, the expense is basically funded by existing surplus.

Finally, a few states place restrictions on which expenses can be included when determining rates. The scenario above regarding whether an extraordinary expense benefits the policyholder is one such example. As another example, some states do not allow an insurer to include charitable contributions or lobbying expenses in its rates. These expenses must be excluded from the calculation of the historical expense ratios when performing the analysis for business written in the state. If such expenses are recurring, overall future income will be reduced by that state's proportion of the expenses.

In the example shown in Table 7.1, there were no extraordinary expenses and a three-year straight average expense ratio is selected.

This procedure is repeated for each of the expense categories. The sum of the selections for each expense category represents the total expense provision. This provision is used directly in the loss ratio or pure premium rate level indication formulae discussed in Chapter 8.

Potential Distortions Using this Approach

By definition, this procedure assumes that all expenses vary directly with premium and there are no fixed expenses yet some expenses may be constant or nearly constant for each risk. By treating all expenses as variable and incorporating them in the rates via a percentage loading, the expense provision in the rates varies directly with the size of the premium. Consequently, this approach understates the premium need for risks with a relatively small policy premium and overstates the premium need for risks with relatively large policy premium.

Returning to the simple example outlined at the onset of the chapter, the \$20 of fixed expense ($\bar{E}_F$) will be included as a percentage with the other 15% of variable expenses (V). Using the final premium of \$250, the \$20 can be converted into a ratio of 8% (= \$20 / \$250). Treating all expenses as variable, the premium calculation becomes:

$$\bar{P} = \frac{\left[\bar{L} + \bar{E}_L\right]}{[1.0 - (V + (\bar{E}_F / \bar{P}) - Q_T]} = \frac{\$180}{[1.0 - (0.15 + 0.08) - 0.05]} = \$250.$$

This approach produces the same result (i.e., $250) as the simple example that had the fixed expense included in the numerator as a fixed dollar amount, because the fixed dollar amount of $20 is exactly equivalent to 8% of $250 (i.e., this is the average risk). The following table shows the results of the two methods for risks with a range of average premiums.

7.3 Results of All Variable Expense Method

	Correct Premium			All Variable Expense Method			
Loss Cost	Fixed Expense	Variable Expense and Profit	Premium	Fixed Expense	Variable Expense and Profit	Premium	% Diff
$ 135	$ 20	20%	$ 193.75	$ -	28%	$ 187.50	-3.2%
$ 180	$ 20	20%	$ 250.00	$ -	28%	$ 250.00	0.0%
$ 225	$ 20	20%	$ 306.25	$ -	28%	$ 312.50	2.0%

As can be seen by the table, the All Variable Expense Method undercharges the risks with premium less than the average and overcharges the risks with premium more than the average.

In recognition of this inequity, companies that use this approach may implement a premium discount structure that reduces the expense loadings based on the amount of policy premium charged. This is common for workers compensation insurers and will be discussed in detail in Chapter 11. Some carriers using the All Variable Expense Method may also implement expense constants to cover policy issuance, auditing, and handling expenses that apply uniformly to all policies. The following sections discuss methods for handling fixed expenses more systematically.

PREMIUM-BASED PROJECTION METHOD

For insurance companies that have a significant amount of both fixed and variable underwriting expenses, it is logical to use a methodology that recognizes the two types of expenses separately. One such procedure for handling fixed and variable underwriting expenses separately was the method outlined by David Schofield in "Going from a Pure Premium to a Rate" (Schofield 1998). Like the All Variable Expense Method, this procedure assumes expense ratios during the projected period will be consistent with historical expense ratios (i.e., historical expenses divided by historical premium). The major enhancement is that this approach calculates fixed and variable expense ratios separately (as opposed to a single variable expense ratio) so that each can be handled more appropriately within the indication formulae.[24]

Table 7.4 shows the relevant calculations for the general expenses category.

[24] As discussed in Chapter 8

7.4 General Expense Provisions Premium-Based Projection Method

	2013	2014	2015	3-Year Average	Selected
a Countrywide Expenses	$26,531,974	$28,702,771	$31,195,169		
b Countrywide Earned Premium	$450,000,000	$490,950,000	$530,000,000		
c Ratio [(a) / (b)]	5.9%	5.8%	5.9%	5.9%	5.9%
d % Assumed Fixed					75.0%
e Fixed Expense % [(c) x (d)]					4.4%
f Variable Expense % [(c) x (1.0-(d))]					1.5%

As with the All Variable Expense Method, the first step of this procedure is to determine the percentage of premium attributable to each type of expense. A ratio is calculated for each expense category by dividing the relevant historical underwriting expenses by either written or earned premium for each year during the historical experience period. As before, the choice of premium measure depends on whether the expenses are generally incurred at the onset of the policy or throughout the policy term. In the example, general expenses are assumed to be incurred throughout the policy period, and thus are divided by earned premium.

The expense ratios are calculated for each year as well as the arithmetic average of the three years. A selection is made using the same considerations discussed earlier. For this example, the general expense ratios are very stable and the three-year average ratio is selected. In contrast, if the ratios demonstrated a trend over time, the actuary may select the most recent year's ratio or some other value.

The selected expense ratio is then divided into fixed and variable ratios. Ideally, the company has detailed expense data so that this division can be made directly, or the company has activity-based cost studies that help split each expense category appropriately. In the absence of any such data, the actuary should consult with other professionals within the company to arrive at the best possible assumptions for allocating the company's expenses. The example assumes 75% of the general expenses are fixed, and that percentage is used to split the selected general expense ratio of 5.9% into a fixed expense provision of 4.4% and a variable expense provision of 1.5%.

The fixed and variable expense ratios are summed across the different expense categories to determine total fixed and variable expense provisions. If the analyst needs the average fixed expense per exposure (which is required for the pure premium approach discussed in Chapter 8) instead of a fixed expense ratio, the fixed expense provision can be multiplied by the projected average premium (trending premium into the projection period was discussed in Chapter 5).

$$\text{Fixed Expense Per Exposure} = \text{Fixed Expense Ratio} \times \text{Projected Average Premium}.$$

Potential Distortions Using this Approach

This approach presupposes that the historical fixed and variable expense ratios will be the same as in the projected period. (Of course, the actuary can select other than the historical ratios.) Since the variable expenses (e.g., commissions) vary directly with premium, the historical variable expense ratio will likely be appropriate. However, since the fixed expenses—by definition—do not vary with premium, the fixed expense ratio will be distorted if the historical and projected premium levels are materially different. There are a few circumstances that can cause such a difference to exist.

First, recent rate changes can impact the historical expense ratios and lead to an excessive or inadequate overall rate indication. The historical fixed expense ratios are based on written or earned premium during the historical period. To the extent that rate increases (or decreases) were implemented during or after the historical period, the procedure will tend to overstate (or understate) the expected fixed expenses. The materiality of the distortion depends on the magnitude of rate changes not fully reflected in the historical premium. Also, utilizing three-year historical expense ratios increases the chances of rate changes not being fully reflected in the historical premium. One potential solution to correct this distortion in expense ratios is to restate the historical written or earned premium at current rate level, as was discussed in Chapter 5.

Second, significant differences in average premium between the historical experience period and the projected period can lead to an excessive or inadequate overall rate level indication. Again, the historical expenses are divided by the written or earned premium during that time period. To the extent that there have been distributional shifts that have increased the average premium (e.g., shifts to higher amounts of insurance) or decreased the average premium (e.g., shifts to higher deductibles) without affecting the underwriting expenses, this methodology will tend to overstate or understate the estimated fixed expense ratios, respectively. Interestingly, sometimes the distributional shift can affect both the average premium and average expense levels. For example, a company may incur additional expense by inspecting homes upon renewal; this may also increase the average premium level as inspections may cause the company to increase the amount of insurance required on the home. The magnitude of overstatement or understatement from this distortion depends on the magnitude of difference between the change in average premium and change in average fixed expenses. Using three-year historical expense ratios increases the impact of these premium changes by increasing the amount of time between the historical and projected periods. A potential solution for this is to trend the historical premium to prospective levels, as was discussed in Chapter 5.

Third, the Premium-based Projection Method can create inequitable rates for regional or nationwide carriers if countrywide expense ratios[25] are used and applied to state projected premium to determine the expected fixed expenses. This is essentially allocating fixed expenses to each state based on premium. The average premium level in states can vary due to overall loss cost differences (e.g., coastal states tend to have higher overall homeowners loss costs) as well as distributional differences (e.g., some states have a significantly higher average amount of insurance than other states). If significant variation exists in average rates across the states, a disproportionate share of projected fixed expenses will be allocated to the higher-than-average premium states. Thus, the estimated fixed expenses will be overstated in higher-than-average premium states and understated in the lower-than-average average premium states. If a company tracks fixed expenses by state and calculates fixed expense ratios for each state, then this distortion will not exist.

Return to the simple example outlined at the onset of the chapter. Assuming the historical fixed expense ratio was calculated at a time that the average premium level was $200 rather than $250, then the historical expense ratio is 10% (= $20 / $200) rather than 8% (= $20 / $250). If the 10% is applied to the premium at current rate level, the projected dollars of fixed expense will be $25 (=$10% x $250). Consequently, the overall indicated average premium will be overstated:

[25] State-specific data is usually used for commissions and taxes, licenses, and fees.

$$\overline{P} = \frac{\left[\overline{L} + \overline{E}_L + \overline{E}_F\right]}{[1.0 - V - Q_T]} = \frac{[\$180 + \$25]}{[1.0 - 0.15 - 0.05]} = \$256.25.$$

Each of the aforementioned items can lead to material differences depending on the proportion of each premium dollar needed to pay for fixed expenses and the magnitude of the difference between the historical and projected premium levels. Instead of making the time-consuming adjustments, the actuary can use a fixed expense projection method based on exposures or number of policies.

EXPOSURE/POLICY-BASED PROJECTION METHOD

In this approach, variable expenses are treated the same way as the Premium-based Projection Method, but historical fixed expenses are divided by historical exposures or policy count rather than premium. This methodology uses the concepts outlined by Diana Childs and Ross Currie in "Expense Allocation in Insurance Ratemaking" (Currie 1980).

If fixed expenses are assumed to be constant for each exposure, the historical expenses are divided by exposures. On the other hand, if fixed expenses are assumed to be constant for each policy, then historical expenses are divided by the number of policies. Table 7.5 shows the development of the fixed and variable expenses for the general expenses category. (The example in this section uses exposures, but the procedure is exactly the same if policy counts are used instead.)

7.5 General Expense Provisions Using Exposure-Based Projection Method

	2013	2014	2015	3-Year Average	Selected
a Countrywide Expenses	$26,531,974	$28,702,771	$31,195,169		
b % Assumed Fixed					75.0%
c Fixed Expense $ [(a) x (b)]	$19,898,981	$21,527,078	$23,396,377		
d Countrywide Earned Exposures	4,378,500	4,665,500	4,872,000		
e Fixed Expense Per Exposure [(c) / (d)]	$4.54	$4.61	$4.80	$4.65	$4.65
f Variable Expense $ [(a) x (1.0-(b))]	$ 6,632,994	$ 7,175,693	$ 7,798,792		
g Countrywide Earned Premium	$450,000,000	$490,950,000	$545,250,000		
h Variable Expense % [(f) / (g)]	1.5%	1.5%	1.4%	1.5%	1.5%

As with the Premium-based Projection Method, the expenses are split into variable and fixed components. The same assumption that 75% of general expenses are fixed is used.[26] The fixed expenses are then divided by the exposures for that same time period. As general expenses in this example are assumed to be incurred throughout the policy, the expense dollars are divided by earned exposures rather than written exposures to determine an average expense per exposure for the indicated historical period.

Table 7.6 shows the data used for this procedure for each expense category.

[26] If premiums and expenses are changing at different rates, then fixed expenses as a percentage of total expenses will change over time, but that may not result in a material distortion.

7.6 Data Summization for Exposure/Policy-Based Projection Method

		Divided By	
Expense	**Data Used**	**Fixed**	**Variable**
General	Countrywide	Earned Exposure	Earned Premium
Other Acquisition	Countrywide	Written Exposure	Written Premium
Commissions and Brokerage	Countrywide/State	Written Exposure	Written Premium
Taxes, Licenses, and Fees	State	Written Exposure	Written Premium

As discussed earlier, the selection of an expense ratio for each category is generally based on either the latest year or a multi-year average. Similar values for the projected average expense per exposure imply expenses are increasing or decreasing proportionately to exposures. This relationship may hold for some expenses, but may not be accurate for all fixed expenses due to economies of scale. If the company is growing and the projected average expense per exposure is declining steadily each year, then it is an indication that expenses may not be increasing as quickly as exposures due to economies of scale. If the decline is significant and the actuary believes it is because of economies of scale, then the selection should be adjusted to include the impact of economies of scale given expected growth in the book of business.[27]

As mentioned earlier, non-recurring expense items, one-time changes in expense levels, or anticipated changes in expenses should be considered in making the selection. In the example shown, the three-year average expense ratio is selected. If the rate level indication approach requires that the fixed expense be expressed as a percentage of premium (as is the case with the loss ratio approach discussed in Chapter 8), then the average fixed expense per exposure should be divided by the projected average premium.

$$\text{Projected Fixed Expense Ratio} = \frac{\text{Average Projected Fixed Expense Per Exposure}}{\text{Projected Average Premium}}.$$

The variable expenses are treated the same way under both the Premium-based and Exposure/Policy-based Projection Methods. In other words, the variable expenses are divided by the historical premium. As stated above, the three-year average variable expense provision is selected for this example.

Other Considerations/Enhancements

While the Exposure/Policy-based Projection Method does correct for the distortions inherent in the Premium-based Projection and the All Variable Expense Methods, there are still some shortcomings with this method.

First, like the Premium-based Projection Method, this method requires the actuary to split the expenses into fixed and variable portions. Today, this is generally done judgmentally. Perhaps in the future, activity-based cost studies will more accurately segregate expenses. Sensitivity testing had revealed that the overall indication is not materially impacted by moderate swings in the categorization of expenses.

Second, the method essentially allocates countrywide fixed expenses to each state based on the exposure or policy distribution by state (as it assumes fixed expenses do not vary by exposure or policy). In reality,

[27] If the selected expense trend is based on historical internal expense data (e.g., historical changes in average expense per exposure) rather than external indices, then the trend will implicitly include the impact of economies of scale in the past. Assuming the impact of economies of scale will be the same as in the past, the projected average expense per exposure should be consistent and no further adjustment is necessary.

average fixed expense levels may vary by location (e.g., advertising costs may be higher in some locations than others). If a regional or nationwide carrier considers the variation to be material, the company should try to collect data at a finer level and make the appropriate adjustments. Once again, the cost of the data collection should be balanced against the additional accuracy gained.

Third, some expenses that are considered fixed actually vary by certain characteristics. For example, fixed expenses may vary between new and renewal business. This only affects the overall statewide rate level indication if the distribution of risks for that characteristic is either changing dramatically or varies significantly by state, or both. Even if there is no impact on the overall rate level indication, any material fixed expense cost difference not reflected in the rates will impact the equity of the two groups. To make rates equitable for the example of new versus renewal business, material differences in new and renewal provisions should be reflected with consideration given to varying persistency levels as described by Sholom Feldblum in "Personal Automobile Premiums: An Asset Share Pricing Approach for Property/ Casualty Insurers" (Feldblum 1996).

Finally, the existence of economies of scale in a changing book may lead to increasing or decreasing projected average fixed expense figures. Further studies may reveal techniques for better approximating the relationship between changes in exposures/policies and expenses to assist in capturing the impact of economies of scale. Until then, internal expense trend data and actuarial judgment should suffice for incorporating the impact of economies of scale.

TRENDING EXPENSES

There is an expectation that expenses, like most monetary values, will change over time due to inflationary pressures and other factors.

Variable expenses are, by definition, assumed to be a constant percentage of the premium. For example, commissions may be 10% of premium. The historical expense ratios and other information are used to select a percentage that is to apply to the premium from policies written during the time the rates will be in effect. Thus, the variable expenses will automatically change as the premium changes, so there is no need to trend the variable expense ratio.

Fixed expenses, on the other hand, are assumed to be a constant dollar amount (i.e., an average fixed expense per exposure or policy). There is an expectation that the average fixed expenses will increase over time due to inflationary pressures.

In the Premium-based Projection Method, the fixed expense ratio is the fixed expenses divided by premium. Approaches for trending expenses vary by company. If the average fixed expenses and average premium are changing at the same rate, then the fixed expense ratio will be consistent and no trending is necessary. However, some companies trend the fixed expense ratio, which implies that average fixed expenses are changing at a different rate than average premium. For the purpose of this text, the fixed expense provision calculated using that methodology is not trended.

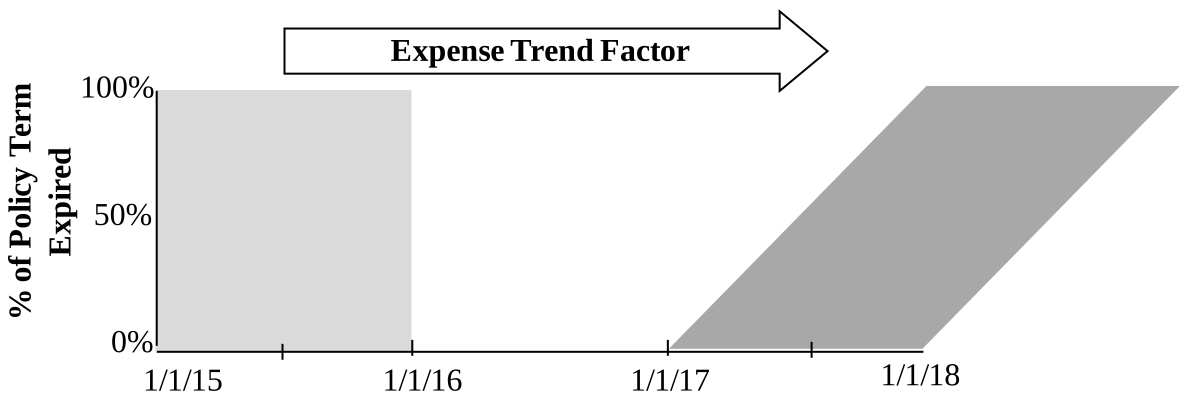
In the Exposure/Policy-based Projection Method, the total fixed expenses are divided by the exposures/policies to calculate the average fixed expense. If an inflation-sensitive exposure base (e.g., payroll per $100) is used, then no trending is necessary if the expenses and exposure base are changing at the same rate. If a non-inflation sensitive base (e.g., car-year or house-year) or policy counts are used, the expectation is that the average fixed expense figure will change over time and trending is appropriate.

Some companies use internal expense data to select an appropriate trend. Similar to the premium and loss trend procedures discussed in earlier chapters, the actuary examines the historical change in average expenses to select an expense trend. Given the volatility of internal data, many companies use government indices (e.g., Consumer Price Index, Employment Cost Index, etc.) and knowledge of anticipated changes in internal company practices to estimate an appropriate trend. One such procedure is shown in Appendix B.

The selected fixed expense ratio will be trended from the average date that expenses were incurred in the historical expense period to the average date that expenses will be incurred in the period that the rates are assumed to be in effect. Thus, the trend period is different for expenses that are incurred at the beginning of the policy and expenses that are incurred throughout the policy.

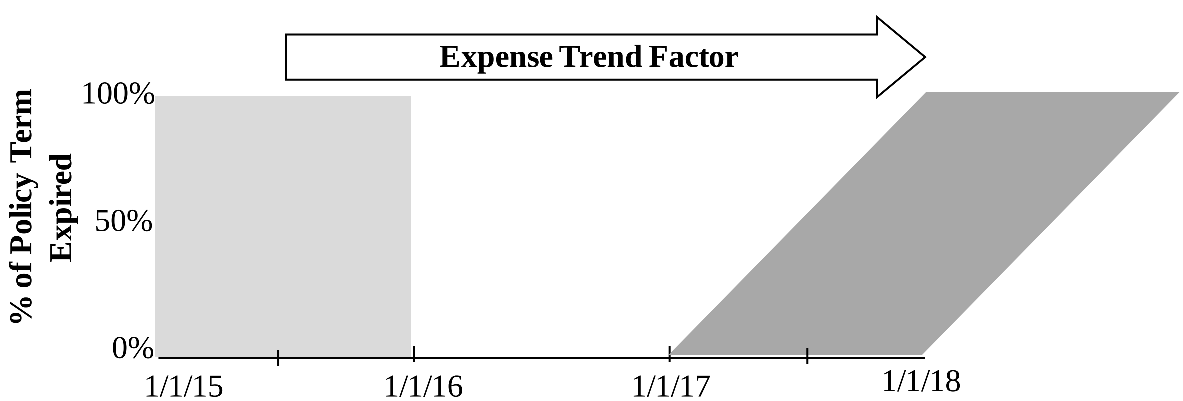
Expenses that are incurred when the policies are written should be trended from the average date that the policies were written in the historical period to the average written date in the projection period. The following figure shows the resulting trend period assuming annual policies are sold, a steady book of business is maintained, and projected rates will be in effect for one year:

7.7 Expenses Incurred at Onset of Policy



In contrast, expenses that are incurred evenly throughout the policy period should be trended from the average date the policies were earned in the historical period to the average earned date in the projection period. The following figure shows the resulting trend period assuming annual policies are sold, a steady book of business is maintained, and the projected rates will be in effect for one year:

7.8 Expenses Incurred Throughout Policy



Since the experience period is a calendar year, the average date the policies are written and earned is the same. However, as demonstrated by the figures, expenses incurred throughout the policy are trended six months longer than expenses incurred at inception. Actuaries may make the simplifying assumption that all expenses are either incurred at the inception of the policy or are incurred evenly throughout the policy period. The materiality of this simplification depends on the magnitude of the expense trend and the percentage of premium that fixed expenses represent.

The explanations and graphics shown above are theoretically correct depictions of the expense trend length for each calendar year in the expense experience period. In practice, however, many actuaries choose to trend historical fixed expenses from a single "trend from" date. For example, if the actuary believes a three-year average expense ratio best represents the historical expense period, the "trend from" date for the average ratio would be the midpoint of the three-year period. This gives approximately the same value as trending each year's expense ratio separately and averaging the results. If the selected trend is based on the latest year only, the "trend from" date would be the midpoint of the latest year. Mathematically this is the same as trending each year's expense ratio separately and choosing only the latest year's trended ratio.

After expenses are trended, the expense ratio or average dollar amount of expense is often called the projected (or trended) fixed expense provision.

REINSURANCE COSTS

As mentioned in Chapter 6, some ratemaking analysis is now performed on a net basis (i.e., with consideration of reinsurance). This practice is becoming more common as reinsurance programs have become more extensive and reinsurance costs have increased substantially.

In proportional reinsurance, the primary carrier transfers or "cedes" the same proportion of premium and losses to the reinsurer; this type of reinsurance may not need to be explicitly considered in ratemaking analysis.

With non-proportional reinsurance, the reinsurer agrees to assume some predefined portion of the losses (which are the reinsurance recoverables). The insurer cedes a portion of the premium (which is the cost of the reinsurance). Common examples of non-proportional reinsurance include catastrophe excess-of-loss (e.g., the reinsurer will cover 50% of the losses that exceed $15,000,000 up to $30,000,000 on their entire property book of business in the event of a catastrophe) and per risk excess-of-loss reinsurance (e.g., the reinsurer will cover for specified risks the portion of any large single event that is between $1,000,000 and $5,000,000).

Typically, the projected losses are reduced for any expected non-proportional reinsurance recoveries. Of course, the cost of purchasing the reinsurance must be included too. That is typically done by reducing the total premium by the amount ceded to the reinsurer. Alternatively, the net cost of the non-proportional reinsurance (i.e., the cost of the reinsurance minus the expected recoveries) may be included as an expense item in the overall rate level indication.

UNDERWRITING PROFIT PROVISION

By writing insurance policies, companies are assuming risk and must maintain capital to support that risk. The cost of this capital entitles companies to include a reasonable profit provision in their rates. For insurance, the **total profit** is the sum of underwriting profit and investment income.

$$\text{Total Profit} = \text{Investment Income} + \text{UW Profit}.$$

Investment Income

There are two major sources of **investment income**: investment income on capital and investment income earned on policyholder-supplied funds.

Capital funds belong to the owners of the insurance company and are referred to as equity on the balance sheet. This has also been called policyholder surplus although the funds may be from investors rather than policyholders. Companies invest these funds and earn investment income. There is substantial disagreement as to whether this source of income should be included in ratemaking or not.

Insurers hold and invest money coming from two types of policyholder-supplied funds: unearned premium reserves and loss reserves. Insureds generally pay their premium at the onset of the policy although coverage is provided continuously throughout the entire policy. The insurer holds and invests that money (i.e., unearned premium) until such time it is earned. The insurer also holds and invests funds to pay for claims that have occurred, but have not yet been settled (i.e., loss reserves). The opportunity for investment income from these funds varies significantly from line to line. For lines of business where claims are reported and settled quickly (i.e., short-tailed lines such as personal auto collision coverage or homeowners insurance), there is only a short time between the payment of premium and the settling of claims; consequently, the investment income will be relatively small. For long-tailed lines (e.g., personal auto bodily injury or workers compensation) there may be years between the time the initial premium is paid and all claims are settled; consequently, the opportunity for investment income is much larger.

The projection of investment income is an advanced topic and is outside of the scope of this text. There is a significant amount of actuarial literature in regards to investment income methodologies.

Underwriting Profit

Underwriting profit is the sum of the profits generated from the individual policies and is akin to the profit as defined in other industries. More specifically, the underwriting profit is defined as follows:

$$\text{UW Profit} = \text{Premium} - \text{Losses} - \text{LAE} - \text{UW Expenses}.$$

The actual profit of an insurance policy is not known at the time of sale because the losses, settlement costs, and servicing costs associated with the insurance product are not yet known.

The combination of the underwriting profit and investment income represents the total profit for the company. Typically, the actuary determines the underwriting profit needed to achieve the target total rate of return after consideration of investment income. For some long-tailed lines, the investment income may be large enough that companies can accept an underwriting loss and still achieve the target total rate of return. For short-tailed lines, the investment income potential is lower and the underwriting profit is a larger portion of the total return.

PERMISSIBLE LOSS RATIOS

The expense and profit provisions discussed in this chapter are used to calculate a **variable permissible loss ratio (VPLR)** or the **total permissible loss ratio (PLR)**. These ratios are used directly in the calculation of the overall rate level indications as presented in Chapter 8. The definitions provided below assume that LAE are included with losses in the rate level indication formula.

The variable permissible loss ratio is calculated as follows:

$$\text{VPLR} = 1.0 - \text{Variable Expense \%} - \text{Target Profit \%} = 1.0 - V - Q_T.$$

This can be thought of as the percentage of each premium dollar that is intended to pay for the projected loss and LAE and projected fixed expenses. The remaining portion of each premium dollar is intended to pay for variable expenses and for profit for the company.

The total permissible loss ratio is calculated as follows:

$$\text{PLR} = 1.0 - \text{Total Expense \%} - \text{Target Profit \%} = 1.0 - F - V - Q_T.$$

This can be thought of as the percentage of each premium dollar that is intended to pay for the projected loss and LAE. The remaining portion of each premium dollar is intended to pay for all underwriting expenses and for profit for the company.

If all expenses are treated as variable expenses, the VPLR and PLR are the same. If LAE are not included with historical losses (but maybe included with underwriting expenses) in the rate level indication formula, the definition of VPLR and PLR must be adjusted. An example of this is provided in Appendix C.

SUMMARY

The rate an insurance company charges must be adequate to cover all costs associated with the insurance policy. These costs include underwriting expenses (i.e., general expenses, other acquisition, commissions and brokerage, and taxes, license, and fees). Some of these expenses vary directly with premium and are called variable expenses; other expenses are assumed to be the same for each risk (i.e., exposure or policy) and are called fixed expenses.

There are three common approaches used to project underwriting expenses: the All Variable Method, the Premium-based Projection Method, and the Exposure/Policy-based Projection method. The first two approaches have historical precedence. The latter approach addresses some distortions that can result from the other methods if fixed expenses are a significant portion of total expenses.

In addition to underwriting expenses (and the loss adjustment expenses covered in Chapter 6), companies may also explicitly consider the cost of reinsurance as an expense in a ratemaking analysis.

Companies are entitled to a reasonable expected profit. The two main sources of profit for insurance companies are investment income and underwriting profit. Traditionally, an underwriting profit provision is selected such that there is a reasonable expectation that the underwriting profit and investment income will generate total profit to appropriately compensate the insurer for the risk assumed.

KEY CONCEPTS IN CHAPTER 7

1. Types of underwriting expenses
    a. Commissions and brokerage
    b. Other acquisition costs
    c. Taxes, licenses, and fees
    d. General expenses

2. Fixed and variable expenses

3. Expense projection methods
    a. All Variable Expense Method
    b. Premium-Based Projection Method
    c. Exposure/Policy-Based Projection Method

4. Expense trending

5. Reinsurance costs

6. Underwriting profit provision

7. Permissible loss ratios
    a. Variable permissible loss ratios
    b. Total permissible loss ratios

CHAPTER 8: OVERALL INDICATION

The goal of a ratemaking analysis is to set the rates such that the premium charged will be appropriate to cover the losses and expenses while achieving the targeted profit for policies that will be written during a future time period. As stated in earlier chapters, this relationship is described by the fundamental insurance equation:

$$\text{Premium} = \text{Losses} + \text{LAE} + \text{UW Expenses} + \text{UW Profit}.$$

The preceding chapters provided techniques for adjusting historical data to estimate the various components of the fundamental insurance equation for the relevant pricing time period. This chapter will demonstrate how to combine the various estimated components to ascertain whether the current rates are appropriate (i.e., whether the profit target is likely to be met at the current rates). Please note that the techniques in this chapter are focused on whether the rates are appropriate in the aggregate. In other words, the focus is to determine appropriate overall indicated rates or indicated rate level changes. Chapters 9-11 discuss the calculation of indications by subclasses of insureds. Chapter 14 details how to calculate final rates based on the overall indications and indications by subclasses of insureds.

There are two basic approaches for determining an overall rate level need:

1. Pure premium method
2. Loss ratio method

This chapter will discuss each of these in detail, demonstrate the mathematical equivalency of the approaches, and discuss rationale for selecting one over the other.

PURE PREMIUM METHOD

The pure premium method is generally considered the simpler and more direct of the two ratemaking formulae as it determines an indicated average rate, not an indicated change to the current average rate. The pure premium method involves projecting the average loss and loss adjustment expenses per exposure and the average fixed expenses per exposure to the period that the rates will be in effect. The sum of those two is then adjusted for variable expenses and the target profit percentage by dividing by one minus the sum of the variable expense provision and target profit percentage (i.e., the variable permissible loss ratio).

The indicated average rate per exposure can be calculated using the pure premium indication formula:

$$\text{Indicated Average Rate} = \frac{\text{Pure Premium (including LAE)} + \text{Fixed UW Expense Per Exposure}}{1.0 - \text{Variable Expense \%} - \text{Target UW Profit \%}}.$$

This is referred to as the indicated average rate per exposure (or the indicated average premium per exposure). Using the earlier notation, the formula can be rewritten as:

$$\overline{P_{\mathrm{I}}} = \frac{\left[\overline{L+E_{\mathrm{L}}} + \overline{E_{\mathrm{F}}}\right]}{\left[1.0 - V - Q_{\mathrm{T}}\right]} = \frac{\left[\left(L+E_{\mathrm{L}}\right)\!/X + E_{\mathrm{F}}/X\right]}{\left[1.0 - V - Q_{\mathrm{T}}\right]}.$$

Derivation of Pure Premium Indicated Rate Formula

To better understand the pure premium indicated rate formula, it is helpful to demonstrate the relationship between the formula and the fundamental insurance equation. Start with the fundamental insurance equation:

$$\text{Premium} = \text{Losses} + \text{LAE} + \text{UW Expenses} + \text{UW Profit}.$$

Using the aforementioned notation, the fundamental insurance equation can be rewritten in the following form:

$$P_{\mathrm{I}} = L + E_{\mathrm{L}} + \left(E_{\mathrm{F}} + V \times P_{\mathrm{I}}\right) + (Q_{\mathrm{T}} \times P_{\mathrm{I}}).$$

By simply rearranging the terms, the formula becomes:

$$P_{\mathrm{I}} - V \times P_{\mathrm{I}} - Q_{\mathrm{T}} \times P_{\mathrm{I}} = \left(L + E_{\mathrm{L}}\right) + E_{\mathrm{F}}.$$

Using basic algebra, the preceding formula is transformed as follows:

$$P_{\mathrm{I}} \times \left[1.0 - V - Q_{\mathrm{T}}\right] = \left(L + E_{\mathrm{L}}\right) + E_{\mathrm{F}}.$$

Dividing both sides of the equation by [1-V-Q_{T}], the formula becomes:

$$P_{\mathrm{I}} = \frac{\left(L + E_{\mathrm{L}}\right) + E_{\mathrm{F}}}{\left[1.0 - V - Q_{\mathrm{T}}\right]}.$$

Dividing both sides of the equation by the number of exposures converts each of the component terms into averages per exposure, and the formula becomes the pure premium indication formula:

$$P_{\mathrm{I}}/X = \frac{\left[\left(L+E_{\mathrm{L}}\right)\!/X + E_{\mathrm{F}}/X\right]}{\left[1.0 - V - Q_{\mathrm{T}}\right]} = \frac{\left[\overline{L+E_{\mathrm{L}}} + \overline{E_{\mathrm{F}}}\right]}{\left[1.0 - V - Q_{\mathrm{T}}\right]} = \overline{P_{\mathrm{I}}}.$$

Simple Example of Pure Premium Indicated Rate Formula

Given the following information:

- Projected pure premium including LAE = \$300
- Projected fixed UW expense per exposure = \$25
- Variable expense % = 25%
- Target UW profit % = 10%

The indicated average rate per exposure can be calculated as follows:

$$\text{Indicated Average Rate} = \frac{\left[\overline{L+E_{\text{L}}} + \overline{E_{\text{F}}}\right]}{\left[1.0 - V - Q_{\text{T}}\right]} = \frac{\left[\$300 + \$25\right]}{\left[1.0 - 25\% - 10\%\right]} = \$500 .$$

New Company

When the actuary is trying to determine rates for a new company, there will be no internal historical data. In such cases, the actuary can still determine the indicated rate by estimating the expected pure premium and expense provisions and selecting a target profit provision. These estimates may be based on external data or determined judgmentally.

LOSS RATIO METHOD

The loss ratio method is the more widely used of the two rate level indication approaches. This approach compares the estimated percentage of each premium dollar needed to cover future losses, loss adjustment expenses, and other fixed expenses to the amount of each premium dollar that is available to pay for such costs. In other words, this method compares the sum of the projected loss and LAE ratio and the projected fixed expense ratio to the variable permissible loss ratio. That relationship can be written as follows:

$$\text{Indicated Change Factor} = \frac{\left[\text{Loss \& LAE Ratio} + \text{Fixed Expense Ratio}\right]}{\left[1.0 - \text{Variable Expense \%} - \text{Target UW Profit \%}\right]}.$$

To the extent that the numerator and denominator are not in-balance, the indicated change factor will be something other than 1.0. The resulting factor can be applied to the current premium to bring the formula back in balance.

Using the same notation, the loss ratio indication formula can be rewritten as follows:

$$\text{Indicated Change Factor} = \frac{\left[\left(L+E_{\text{L}}\right)/P_{\text{C}} + F\right]}{\left[1.0 - V - Q_{\text{T}}\right]}.$$

This is commonly rewritten as an indicated change by subtracting 1.0:

$$\text{Indicated Change} = \frac{\left[\left(L+E_{\text{L}}\right)/P_{\text{C}} + F\right]}{\left[1.0 - V - Q_{\text{T}}\right]} - 1.0.$$

Derivation of Loss Ratio Indicated Rate Change Formula

To better understand the loss ratio indicated rate change formula, it is helpful to demonstrate the relationship between the formula and the fundamental insurance equation. Start with the fundamental insurance equation:

$$\text{Premium} = \text{Losses} + \text{LAE} + \text{UW Expenses} + \text{UW Profit}.$$

Using the aforementioned notation with respect to premium and profit at current rates, the fundamental insurance equation can be rewritten in the following form:

$$P_C = L + E_L + (E_F + V \times P_C) + Q_C \times P_C.$$

By simply rearranging the terms, the formula becomes:

$$Q_C \times P_C = P_C - (L + E_L) - (E_F + V \times P_C).$$

Dividing each side by the projected premium at current rate level (P_C) yields:

$$Q_C = 1.0 - \frac{(L + E_L) + (E_F + V \times P_C)}{P_C} = 1.0 - \frac{L}{P_C} - \left(\frac{E_L + E_F}{P_C} + V\right).$$

When the terminology introduced in Chapter 1 is substituted for the symbols, the formula becomes more intuitive:

$$\text{Profit \% at Current Rates} = 1.0 - \text{Loss Ratio} - \text{OER} = 1.0 - \text{Combined Ratio}.$$

Again, the goal of the ratemaking exercise is to determine whether the current rates are appropriate to cover the estimated losses and expenses and produce the target profit. If the expected profit percentage assuming current rates (Q_C) is equivalent to the target profit percentage (Q_T) then the current rates are appropriate. The more likely case is that the expected profit percentage assuming current rates (Q_C) is not equivalent to the target profit percentage (Q_T), and the rates need to be adjusted.

Slightly reordering the prior formula gives:

$$Q_C = 1.0 - \frac{(L + E_L) + E_F}{P_C} - V.$$

The objective is to determine how much the premium at current rates needs to be increased or decreased to achieve the target profit percentage. To do this, it is necessary to substitute the target profit percentage (Q_T) for the expected profit percentage assuming current rates (Q_C) and the indicated premium (P_I) for the projected premium at current rates (P_C). The indicated premium can be represented as the product of the projected premium at current rates and the indicated change factor:

$$Q_T = 1.0 - \frac{(L + E_L) + E_F}{P_C \times \text{Indicated Change Factor}} - V.$$

The terms can be rearranged as follows:

$$1.0 - V - Q_T = \frac{(L + E_L) + E_F}{P_C \times \text{Indicated Change Factor}}.$$

Rearranging the components via cross multiplication and dividing through by P_C yields:

$$\text{Indicated Change Factor} = \frac{L + E_L + E_F}{P_C \times (1.0 - V - Q_T)} = \frac{(L + E_L)/P_C + E_F/P_C}{(1.0 - V - Q_T)},$$

which is equivalent to the loss ratio indication formula derived earlier:

$$\text{Indicated Change Factor} = \frac{\left[(L + E_L)/P_C + F\right]}{\left[1.0 - V - Q_T\right]}.$$

A result greater than 1.0 means the current rates are inadequate and need to be adjusted upward; for example, a result of 1.05 means the current rates should be adjusted upward by 5%. Similarly, a result less than 1.0 means the current rates are excessive and need to be reduced; for example, a result of 0.98 means the current rates should be reduced by 2%. Subtracting 1.0 from both sides produces an indicated change as follows:

$$\text{Indicated Change} = \frac{\left[(L + E_L)/P_C + F\right]}{\left[1.0 - V - Q_T\right]} - 1.0.$$

Simple Example of Loss Ratio Indicated Rate Change Formula

Assume the following information:

- Projected ultimate loss and LAE ratio = 65%
- Projected fixed expense ratio = 6.5%
- Variable expense % = 25%
- Target UW profit % = 10%

The indicated rate change can be calculated as follows:

$$\text{Indicated Change} = \frac{\left[(L + E_L)/P_C + F\right]}{\left[1.0 - V - Q_T\right]} - 1.0 = \frac{[65\% + 6.5\%]}{[1.00 - 25\% - 10\%]} - 1.0 = 10\%.$$

This means that overall average rate level is inadequate and should be increased by 10%.

New Company

Since the loss ratio approach is dependent on current premium, it is only used for ratemaking analysis involving an existing company.

LOSS RATIO VERSUS PURE PREMIUM METHODS

Now that the two different rate level approaches have been discussed, it is important to understand whether the two approaches will produce equivalent results and the relative strengths and weaknesses of each.

Comparison of Approaches

There are two major differences between the two approaches. One major difference is the underlying loss measure used. The loss ratio indication formula relies on the loss ratio (i.e., projected ultimate losses and LAE divided by projected premium at current rate level), and the pure premium indication formula relies on the pure premium statistic (i.e., projected ultimate losses and LAE divided by projected exposures). The significance of this difference is that the loss ratio indication formula requires premium at current rate level and the pure premium indication formula does not. Similarly, the pure premium indication formula requires clearly defined exposures whereas the loss ratio indication formula does not.

Due to this difference, the pure premium approach is preferable if premium is not available or if it is very difficult to accurately calculate premium at current rate level. For example, the rating algorithm for some insurance products (e.g., personal automobile insurance) may include a large number of rating variables. If there were a significant number of changes made to those variables during the historical period, it may be difficult to calculate the premium at current rate level. In contrast, the loss ratio method is preferable if exposure data is not available or if the product being priced does not have clearly defined exposures. For example, commercial general liability (CGL) policies have multiple sub-lines intended to protect policyholders against a broad range of risks; as such, CGL policies can have different exposure bases for the various sub-lines included. Consequently, when pricing CGL, it may be easier to obtain and use premium at current rate level rather than trying to define a consistent exposure.

The other major difference is that the output of the two formulae is different. The result of the loss ratio indication formula is an indicated change to the currently charged rates. In contrast, the result of the pure premium formula is an indicated rate. Because of this difference, the pure premium method must be used with a new line of business for which there are no current rates to adjust.

Some actuaries prefer to express rate need in terms of a percent change to existing rates. This percent change approximates the average impact on existing policyholders if the fully indicated rates are implemented (ignoring any changes in policyholder retention). Consequently, the loss ratio method may be preferred to the pure premium method in this case. If the pure premium approach is used, however, the indicated change is easily calculated by comparing the indicated rate to the current rate.

Equivalency of Methods

Since both formulae can be derived from the fundamental insurance equation, it should be understood that the two approaches are mathematically equivalent. To illustrate the point more clearly, the following shows the reconciliation of the two approaches.

Start with the loss ratio indication formula:

$$\text{Indicated Change Factor} = \frac{\left[\left(L + E_{\text{L}} \right) / P_{\text{C}} + F \right]}{\left[1.0 - V - Q_{\text{T}} \right]}.$$

This formula can be restated as follows:

$$\text{Indicated Change Factor} = \frac{\left[\frac{(L+E_L)}{P_C} + \frac{E_F}{P_C} \right]}{[1.0 - V - Q_T]}.$$

Recognizing that the indicated adjustment factor is equivalent to the ratio of the indicated premium (P_I) to the projected premium assuming current rates (P_C) yields the following:

$$\frac{P_I}{P_C} = \frac{\left[\frac{(L+E_L)}{P_C} + \frac{E_F}{P_C} \right]}{[1.0 - V - Q_T]}.$$

Multiplying both sides by the projected average premium assuming current rates (P_C/X) results in the pure premium indication formula:

$$\frac{P_I}{X} = \frac{\left[\frac{(L+E_L)}{X} + \frac{E_F}{X} \right]}{[1.0 - V - Q_T]} = \frac{\left[\overline{L+E_L} + \overline{E_F}\right]}{[1.0 - V - Q_T]}.$$

The preceding proof clearly shows the two approaches are equivalent. However, the equivalency of the two formulae depends on consistent data and assumptions being used for both approaches. To the extent that does not happen, it is possible that the approaches will produce different results. For example, if the premium at current rate level is estimated using the parallelogram method rather than the more accurate extension of exposures method, any inaccuracy introduced by the approximation may result in inconsistency between the loss ratio and pure premium methods.

INDICATION EXAMPLES

This and the preceding chapters have provided different techniques that can be used to determine an overall rate level indication. The exact techniques used by the actuary will vary depending on a variety of factors, including unique characteristics of the product being priced, data limitations, historical precedence, and regulatory constraints.

Appendices A-D provide overall rate level indication examples for four different insurance products. Each of these example indications is based on several years of subject experience. Calculating the total loss ratio (or pure premium) can be done in different ways. Many companies sum projected ultimate loss and LAE across all years and divide by projected earned premium at present rates (or projected exposures) across all years. This is equivalent to weighting each year’s loss and LAE ratio (pure premium) by the relevant premium (or exposure). Alternatively, some companies select weights for each accident year’s experience, often giving more weight to the more recent years.

SUMMARY

The preceding chapters show how to adjust historical data to prospective levels. This chapter demonstrates two methods for combining the prospective estimates to determine the appropriate rate level for a future time period: the pure premium method and the loss ratio method.

The pure premium method's main statistic is the pure premium and the outcome of the approach is an indicated average rate. As such, the pure premium approach relies on exposures rather than premium and is most appropriate for pricing new lines of business or situations when the premium at current rate level is difficult to calculate.

The loss ratio method's main statistic is the loss ratio and the outcome of the approach is an indicated adjustment to the current rates. This approach relies on premium rather than exposures, and it is most appropriate for pricing lines of business for which there are not clearly defined exposures or where the indicated rate change is a critically important statistic for the final pricing decision.

Using consistent data and assumptions, the two approaches are mathematically equivalent.

KEY CONCEPTS IN CHAPTER 8

1. Pure premium indication formula

$$\text{Indicated Average Rate} = \frac{\text{Pure Premium (including LAE)} + \text{Fixed UW Expense Per Exposure}}{\text{1.0 - Variable Expense \% - Target UW Profit \%}}$$

$$\text{Indicated Average Rate} = \frac{\left[(L + E_L)/X + E_F/X \right]}{\left[1.0 - V - Q_T \right]} = \frac{\left[\overline{L + E_L} + \overline{E_F} \right]}{\left[1.0 - V - Q_T \right]}.$$

2. Loss ratio indication formula

$$\text{Indicated Change} = \frac{\left[\text{Loss \& LAE Ratio} + \text{Fixed Expense Ratio} \right]}{\left[\text{1.0} - \text{Variable Expense \%} - \text{Target UW Profit \%} \right]} - 1.0$$

$$\text{Indicated Change} = \frac{\left[(L + E_L)/P_C + F \right]}{\left[1.0 - V - Q_T \right]} - 1.0$$

3. Loss ratio versus pure premium method
    a. Strengths and weaknesses of each method
    b. Mathematical equivalency of methods

CHAPTER 9: TRADITIONAL RISK CLASSIFICATION

The preceding chapters focused on making sure the fundamental insurance equation is in balance in the aggregate (i.e., the total premium should cover the total costs and allow for the target underwriting profit). In addition to focusing on the aggregate, it is important for the actuary to be able to develop a balanced indication for individual risks or risk segments, too. Of course, other considerations (e.g., marketing, operational, and regulatory) may cause management to implement a rating algorithm other than what is indicated by the actuary's analysis.

Some very large risks have a significant amount of individual experience. For example, a multi-billion dollar manufacturing corporation may purchase insurance for various plants for property damage, commercial liability, and workers compensation. For these risks, it may be possible for an insurer to use the risk's individual historical experience to reasonably estimate the amount of premium required for a future policy term. Such risks are priced using rating techniques covered in Chapter 15. For most insurance products, however, it is not feasible to set rates for an individual risk using solely the historical experience of that individual risk. In such cases, risks must be analyzed via **classification ratemaking**, which is the process of grouping risks with similar loss potential and charging different manual rates to reflect differences in loss potential among the groups.

The first stage of classification ratemaking involves determining which risk criteria effectively segment risks into groups with similar expected loss experience. For example, a homeowners insurer may recognize that the expected loss for a homeowners policy varies materially based on the age of the home. The characteristic being examined is often referred to as a rating variable. Some companies draw a distinction between underwriting and rating variables. In this text, the term rating variable refers to any variable used to vary rates, even if it is based on a characteristic normally considered an underwriting characteristic. The different values of the rating variable are referred to as levels. In the example given, age of the home is the rating variable, and the different ages or age ranges are the levels.

Once the insured population is subdivided into appropriate levels for each rating variable, the actuary calculates the indicated rate differential relative to the base level for each level being priced. If a rate differential is applied multiplicatively, it is often referred to as a rate relativity. If the rate differential is applied additively, it is generally referred to as an additive. Sometimes actuaries use the term class to refer to a group of insureds that belong to the same level for each of several rating variables. For example, personal lines auto insurers frequently use the term class to refer to a group of insureds with the same age, gender, and marital status.

This chapter discusses:

- The importance of charging equitable rates
- Criteria for evaluating potential rating variables
- Traditional univariate (one-way) techniques used to estimate the appropriate rate differentials for various levels of a given rating variable, including distortions introduced by each

In order to eliminate the distortions inherent in univariate techniques, many actuaries use multivariate classification ratemaking techniques, which are discussed in Chapter 10. Also, Chapter 11 outlines special classification ratemaking techniques used for certain rating variables.

IMPORTANCE OF EQUITABLE RATES

The prior chapters have provided significant detail as to the techniques an actuary should use to calculate rates that give a reasonable expectation of achieving the target profit in total. It may seem like the company should be satisfied as long as the rates are expected to produce the desired aggregate target profit and should not, therefore, be overly concerned with individual rate equity. In reality, a company that fails to charge the right rate for individual risks when other companies are doing so may be subjected to adverse selection, and consequently, deteriorating financial results. Also, a company that differentiates risks using a valid risk characteristic that other companies are not using may achieve favorable selection and gain a competitive advantage.

Adverse Selection

The goal of classification ratemaking is to determine a rate that is commensurate with the individual risk. Consider the situation in which a company (e.g., Simple Company) charges an average rate for all risks when other competing companies have implemented a rating variable that varies rates to recognize the differences in expected costs. In this case, Simple Company will attract and retain the higher-risk insureds and lose the lower-risk insureds to other competing companies where lower rates are available. This results in a distributional shift toward higher-risk insureds that makes Simple Company's previously "average" rate inadequate and causes the company to be unprofitable. Consequently, Simple Company must raise the average rate. The increase in the average rate will encourage more lower-risk insureds to switch to a competing company, which causes the revised average rate to be unprofitable. This downward spiral will continue until Simple Company improves their rate segmentation, becomes insolvent, or decides to narrow their focus solely to higher-risk insureds and raises rates accordingly. This process is referred to as adverse selection. However, the speed and severity of the process depends on various factors, including whether purchasers of insurance have full and accurate knowledge of differences in competitor rates and how much price alone influences their purchasing decisions.

The adverse selection cycle can be demonstrated by expanding the simple pricing example used in prior chapters. For the purpose of demonstrating adverse selection, the assumptions are as follows:

- The average loss ($\bar{L}$) and LAE ($\overline{E_L}$) is $180. There are no underwriting expenses or profit, so the average total cost is $180, and rates are set accordingly.
- The insured population consists of 50,000 high-risk insureds (Level H) and 50,000 low-risk insureds (Level L).
- The insurance market consists of two companies (Simple Company and Refined Company) that each currently insure 25,000 of each class of risk.
- H risks have a cost of $230, and L risks have a cost of $130.
- Simple Company charges H and L risks the same rate, $180. Refined Company implements a rating variable to vary the rates according to the cost and, therefore, charges H and L risks $230 and $130, respectively.
- 1 out of every 10 insureds shops at renewal and bases the purchasing decision on price.

Originally, the risks are distributed evenly amongst the two companies and the rates are set as follows:

9.1 Original Distribution, Loss Cost, and Rates

Risk	(1) True Expected Cost	(2) Refined Company Insured Risks	(3) Refined Company Charged Rate	(4) Simple Company Insured Risks	(5) Simple Company Charged Rate
H	$ 230.00	25,000	$ 230.00	25,000	$ 180.00
L	$ 130.00	25,000	$ 130.00	25,000	$ 180.00
Total	$ 180.00	50,000	$ 180.00	50,000	$ 180.00

As can be seen on the following table, if the distribution is static (i.e., there is no movement of risks between companies), the aggregate amount of premium collected is the same for both companies. For Refined Company, the premium charged varies by each level of the rating variable and is equitable. For Simple Company, the premium charged is too little for the H risks. There is a shortfall of $1,250,000, which is completely offset by the excess premium collected from L risks. In other words, the L risks are subsidizing the H risks at Simple Company.

9.2 Static Distribution With Results

Risk	(1) True Expected Cost	(2) Refined Company Insured Risks	(3) Refined Company Charged Rate	(4) Refined Company Total $Excess/ ($Shortfall)	(5) Simple Company Insured Risks	(6) Simple Company Charged Rate	(7) Simple Company Total $Excess/ ($Shortfall)
H	$ 230.00	25,000	$ 230.00	$ -	25,000	$ 180.00	$ (1,250,000)
L	$ 130.00	25,000	$ 130.00	$ -	25,000	$ 180.00	$ 1,250,000
Total	$ 180.00	50,000	$ 180.00	$ -	50,000	$ 180.00	$ -

(4)= [(3)-(1)] x (2)
(7)= [(6)-(1)] x (5)

Given the assumption that 1 out of 10 insureds shops at renewal and makes the purchase decision based on price, the distribution will not remain static. The H risks who shop will choose Simple Company, and the L risks who shop will choose Refined Company. This movement results in the following distribution of risks for policy year one:

9.3 Policy Year One Distribution With Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Refined Company			Simple Company		
Risk	True Expected Cost	Insured Risks	Charged Rate	Total $Excess/ ($Shortfall)	Insured Risks	Charged Rate	Total $Excess/ ($Shortfall)
H	$ 230.00	22,500	$ 230.00	$ -	27,500	$ 180.00	$ (1,375,000)
L	$ 130.00	27,500	$ 130.00	$ -	22,500	$ 180.00	$ 1,125,000
Total	$ 180.00	50,000	$ 175.00	$ -	50,000	$ 180.00	$ (250,000)

(4)= [(3)-(1)] x (2)
(7)= [(6)-(1)] x (5)

Because Refined Company charges the right rate for each class, there is still no excess or shortfall (as both their total premium and total costs will be proportionately lower). Because Simple Company's distribution has shifted toward more H risks, the excess premium from the L risks fails to make up for the shortfall from the H risks; therefore, Simple Company loses money in policy year one. In order to correct for the $250,000 shortfall, Simple Company is forced to increase the rate from $180 to $185, the new average cost based on the new distribution.

Unless Simple Company segments its portfolio in a more refined manner, this cycle will continue each year. More specifically, the H risks will continue to shift to Simple Company, and the L risks will continue to shift toward Refined Company. Since Refined Company is charging equitable rates, there will be no excess or shortfall. Conversely, Simple Company continues to charge an average rate based on the prior distribution, and there will be a shortfall each year as the distribution changes. Thus, Simple Company will need to keep taking rate increases. By policy year five, the results will be as follows:

9.4 Policy Year Five Distribution With Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Refined Company			Simple Company		
Risk	True Expected Cost	Insured Risks	Charged Rate	Total $Excess/ ($Shortfall)	Insured Risks	Charged Rate	Total $Excess/ ($Shortfall)
H	$ 230.00	14,762	$ 230.00	$ -	35,238	$ 197.20	$ (1,155,798)
L	$ 130.00	35,238	$ 130.00	$ -	14,762	$ 197.20	$ 992,023
Total	$ 180.00	50,000	$ 159.52	$ -	50,000	$ 197.20	$ (163,775)

(4)= [(3)-(1)] x (2)
(7)= [(6)-(1)] x (5)

This trend will continue until such time that Simple Company begins to segment in a more refined manner, loses too much money to continue, or only insures H risks at the rate of $230. Since Refined Company maintains a rate appropriate for both H and L risks, they are able to write both types of risk competitively and profitably.

Note that this was a very simple example with simple assumptions intended to demonstrate the adverse selection cycle. In reality, there are many factors that will affect the adverse selection cycle. For example, the assumption that Simple Company increased rates to the new true average cost each year may not be entirely feasible. Many jurisdictions require a company to obtain approval to change rates. Any delay in regulatory approval can lead to delays that would only exacerbate the profitability issues for Simple Company.

Favorable Selection

Adverse selection deals with the case where a company fails to segment based on a meaningful characteristic that other companies are using, or fails to charge an appropriate differential for a rating variable that other companies are charging appropriately. Conversely, when a company identifies a characteristic that differentiates risk that other companies are not using, the company has two options for making use of this information:

1. Implement a new rating variable.
2. Use the characteristic for purposes outside of ratemaking (e.g., for risk selection, marketing, agency management).

If the company chooses to implement a new rating variable and prices it appropriately, its new rates will be more equitable. This may allow the company to write a segment of risks that were previously considered uninsurable. If the company is already writing a broad spectrum of risks, then implementation of a new rating variable will have the opposite effect of adverse selection. In other words, the company will attract more lower-risk insureds at a profit. Some of the higher-risk insureds will remain; those who remain will be written at a profit, rather than a loss. Over the long run, the company will be better positioned to profitably write a broader range of risks.

The motorcycle insurance market provides a good example of favorable selection. Originally, motorcycle insurers used very simple rating algorithms that did not include any variation based on the age of the operator. The first companies that recognized that the age of the operator is an important predictor of risk implemented higher rates for youthful operators. In order to keep their overall premium revenue neutral, they lowered rates for non-youthful operators. By doing this, the companies were able to attract a large portion of the profitable adult risks from their competitors. Furthermore, those youthful operators who chose to insure with them were written profitably.

In some cases, the company may not be able to (or may choose not to) implement a new or refined rating variable. If allowed by law, the company may continue to charge the average rate but utilize the characteristic to identify, attract, and select the lower-risk insureds that exist in the insured population; this is called "skimming the cream." If the company can effectively focus on attracting and keeping the lower-risk insureds, the company will be more profitable than the competitors. Ultimately, the company will be able to lower the average rate to reflect the better overall quality of the insured risks.

CRITERIA FOR EVALUATING RATING VARIABLES

The first step in classification ratemaking is to identify the rating variables that will be used to segment the insured population into different groups of similar risks for the purposes of rating. For example, a workers compensation carrier needs to decide whether or not the number, type, and skill level of employees are risk characteristics that will be used as rating variables for workers compensation insurance.

This section explains the various criteria for evaluating the appropriateness of rating variables, as set forth by Robert Finger in "Risk Classification" (Finger 2001, pp. 292-301). The criteria can be grouped into the following categories:

- Statistical
- Operational
- Social
- Legal

Statistical Criteria

The rating variables should reflect the variation in expected costs among different groups of insureds. Ideally, the company will have collected or can obtain data that enables it to test the statistical effectiveness of the rating variable being considered.[28] If so, the company should consider the following statistical criteria to help ensure the accuracy and reliability of the potential rating variable:

- Statistical significance
- Homogeneity
- Credibility

The rating variable should be a statistically significant risk differentiator. In other words, the expected cost estimates should vary for the different levels of the rating variable, the estimated differences should be within an acceptable level of statistical confidence, and the estimated differences should be relatively stable from one year to the next. If all the levels for a given rating variable have no statistical variation in loss experience, then the rating variable may not be useful. If instead the estimates of cost differences are different but the results are volatile, then it is less clear whether the rating variable is improving equity or not.

Second, the levels of a rating variable should represent distinct groups of risks with similar expected costs. In other words, the groups should be defined such that the risk potential is homogeneous within groups and heterogeneous between groups. If a group of insureds contains materially different risks, then the risks should be subdivided further by creating more levels of an existing rating variable or by introducing additional rating variables. When considering homogeneity, it is important to differentiate between expected and actual costs. Even truly identical risks may have different loss experience during a given policy period due to the random nature of the insurance events (i.e., even the highest-risk drivers will not necessarily have a claim every policy period and the lowest-risk driver may have a claim). The key for classification analysis is to identify and group risks for which the magnitude and variability of expected costs are similar; by doing so, the actuary will develop more accurate and equitable rates.

Finally, the number of risks in each group should either be large enough or stable enough or both for the actuary to be able to accurately estimate the costs. Actuaries refer to this as having sufficient credibility and this will be discussed in greater detail in Chapter 12. If a particular level of a rating variable includes too few risks or is not stable over time, then the experience may lack the credibility necessary to

[28] The factors can be tested using the techniques described later in this and the following chapters.

accurately estimate the costs. In such cases, the actuary should consider combining similar levels to increase the credibility or look for additional relevant data.

The science of classification requires balancing two objectives: grouping risks into a sufficient number of levels to ensure the risks within each group are homogeneous while being careful not to create too many granularly defined groups that may lead to instability in the estimated costs.

Operational Criteria

Even if a rating variable effectively segments risk, it may not be practical to use in a rating algorithm due to operational considerations. For a rating variable to be considered practical, it should be

- Objective
- Inexpensive to administer
- Verifiable

First, the levels within a rating variable should have objective definitions. For example, it seems logical that the estimated costs for medical malpractice insurance vary by the skill level of a surgeon. However, the skill level of a surgeon is difficult to determine and somewhat subjective; therefore, it is not a practical choice for a rating variable. Instead, companies can use more objective rating variables like board certification, years of experience, and prior medical malpractice claims that serve as proxies for skill level.

Second, the operational cost to obtain the information necessary to properly classify and rate a given risk should not be too high. For example, there are building techniques and features that improve the ability of a home to withstand high winds. If these items significantly reduce expected losses, statistically speaking the company should implement a rating variable to recognize the differences. Unfortunately, the existence of some of the features cannot be easily identified without a very thorough inspection of the home performed by a trained professional. If the cost of the inspection significantly outweighs the potential benefit, then it may not make sense for a company to use that risk characteristic as a rating variable.

Third, the levels of a rating variable should not be easily manipulated by the insured or distribution channel, and should be easy for the insurer to verify. It is generally accepted that the number of miles driven is a risk differentiator for personal auto insurance. However, many car owners cannot accurately estimate how many miles their car will be driven in the upcoming policy period, and even if they can, the insurance companies may not currently have a cost-effective way to verify the accuracy of the amount estimated by the insured. Since some companies feel the insureds may not supply sufficiently accurate information, they have chosen not to use annual miles driven as a rating variable. Note, as technology evolves and on-board diagnostic devices become standard equipment in cars, the verifiability of this rating variable and how it is used in rating may be substantially different.

Social Criteria

Insurance companies are selling insurance products to a variety of consumers; consequently, companies are affected by public perception. The following items affect the social acceptability of using a particular risk characteristic as a rating variable:

- Affordability
- Causality
- Controllability
- Privacy concerns

First, from a social perspective, it is desirable for insurance to be affordable for all risks. This is especially true when insurance is required by law (e.g., states require “proof of financial responsibility” from owners of vehicles and that is most easily achieved though personal automobile insurance) or required by a third party (e.g., lenders require homeowners insurance), or is merely desirable to facilitate ongoing operation (e.g., stores purchase commercial general liability insurance). In some cases, a particular risk characteristic may identify a small group of insureds whose risk level is extremely high, and if used as a rating variable, the resulting premium may be unaffordable for that high-risk class. To the extent that this occurs, companies may wish to or be required by regulators to combine classes and introduce subsidies. For example, 16-year-old drivers are generally higher risk than 17-year-old drivers. Some companies have chosen to use the same rates for 16- and 17-year-old drivers to minimize the affordability issues that arise when a family adds a 16-year-old to the auto policy. The company may be willing to accept the subsidy in recognition of the fact that the policy will be profitable in the long run as the teenager ages. Alternatively, companies have developed new insurance products that can support a lower rate for high-risk insureds by offering less coverage.

Second, in addition to being correlated with expected losses, some risk characteristics directly impact the amount of expected losses. From a social perspective, it is preferable if rating variables are based on characteristics that are causal in nature. For example, most people understand that the presence of a sump pump in a house has a direct effect on water damage losses to the house (both in propensity to have a claim and the severity of the claim). As such, a corresponding reduction in premium for the presence of a sump pump is likely to be socially acceptable. In recent years, personal lines insurers have introduced insurance credit scores, a measure of the insured’s financial responsibility, into rating algorithms. Despite the strong statistical power in predicting losses, the use of this variable has resulted in a consumer backlash stemming from a belief that there is a lack of obvious causality to losses.

Third, it is preferable if an insured has some ability to control the class to which they belong and, consequently, be able to affect the premium charged.[29] For example, the type and quality of a company’s loss control programs can have a significant effect on workers compensation expected losses. This is a controllable rating variable as insured companies can implement approved loss control programs in an

[29] This may seem to contradict the comment made in the operational criteria section that it is undesirable to have a rating variable that can be manipulated by the insured. The operational criterion refers to insureds or others supplying false information to earn a cheaper rate. The controllability criterion refers to the case where an insured can be motivated to improve his risk characteristic and consequently reduce his rate. The latter often has broader societal benefits (e.g., insureds purchasing cars with safety devices that afford insurance discounts).

effort to reduce expected losses and consequently reduce the charged premium. In contrast, insureds cannot control their age or gender. Interestingly, even though age and gender have been demonstrated to influence personal lines loss costs, some jurisdictions do not allow them as rating variables.

Finally, there can be significant privacy concerns associated with the use of particular rating variables. For example, technology exists that can track where a car is being driven and how safely the driver is driving. When the technology is standard in all vehicles, the information could be used to greatly improve the insurance companies' ability to accurately price a given risk. In order to address the privacy concern, the data is deemed to be protected and the insurance company is only able to use it with the express consent of the insured. Some companies have implemented usage-based insurance programs[30] on a voluntary basis. Of course, any such usage-based programs will be most effective if they can be used on all risks rather than just the ones who volunteer.[31]

Legal Criteria

Most jurisdictions around the world have some level of law and regulation related to property and casualty insurance products. Currently in the United States, property and casualty insurance products are regulated by the states. Each state has laws and regulations concerning the pricing of insurance products, and the details vary greatly from state to state and from product to product. Most states have statutes that require insurance rates to be "not excessive, not inadequate, and not unfairly discriminatory." Additionally, some states' statutes may require certain rates to be "actuarially sound." How a state's executive branch interprets these statutes can vary significantly from state to state and even within a particular state over time.

Some states have promulgated regulations that include details about what is allowed and not allowed in risk classification rating for various property and casualty insurance products. It is imperative that the rate classification system be in compliance with the applicable laws and regulations of each jurisdiction in which a company is writing business.

For example, some states have statutes prohibiting the use of gender in rating insurance while others permit it as a rating variable. As a result, an insurer writing in multiple states may include gender as a rating variable in those states where it is permitted, but not include it in a state that prohibits its use for rating. Some states may allow the use of a rating variable, but may place restrictions on its use. For example, some states allow credit score to be used for rating personal insurance for new business, but do not allow insurers to raise the rates for renewal risks should the insured's credit worsen (although they may allow companies to reduce rates if the insured's credit score improves). Some states also prohibit certain variables from use in the rating algorithm but allow their use in underwriting. Underwriting variables may be used to guide risk selection decisions, but could also guide risk placement decisions.[32]

[30]Usage-based insurance programs rely on on-board diagnostic devices to track various criteria about how the car is being driven (e.g., mileage by time of day and rapid changes in speed). The insurer adjusts the next policy term premium based on the usage information reported automatically in the prior term.

[31] The issue is one of self-selection. The only insureds who volunteer for the usage-based programs are those who benefit from it in the way of lower rates. Thus, the data cannot really be used to differentiate the high- and low-risk drivers.

[32] In some cases, placing a risk into a different company or tier may affect the rate (though the criteria are not considered "rating variables" by regulators).

An actuary needs to be familiar with the laws and regulations of each jurisdiction in which his or her company writes insurance and assure that the classification rating is in compliance with that jurisdiction's laws and regulations. This usually requires working with other professionals, such as lawyers or regulatory compliance experts, in determining what is acceptable and what is not.

TYPICAL RATING (OR UNDERWRITING) VARIABLES

The following are a few examples of rating variables by line of business:

9.5 Typical Rating Variables

Type of Insurance	Rating Variables
Personal Automobile	Driver Age and Gender, Model Year, Accident History
Homeowners	Amount of Insurance, Age of Home, Construction Type
Workers Compensation	Occupation Class Code
Commercial General Liability	Classification, Territory, Limit of Liability
Medical Malpractice	Specialty, Territory, Limit of Liability
Commercial Automobile	Driver Class, Territory, Limit of Liability

Note that some risk characteristics may be used as both rating variables and underwriting variables.

DETERMINATION OF INDICATED RATE DIFFERENTIALS

In addition to determining the rating variables and the levels within, the actuary must also identify the amount of rate variation among the levels of each rating variable. As discussed in Chapter 2, a rating variable typically has two or more levels with one level designated as the base level. The rate for all non-base levels is expressed relative to the base level, as prescribed in the rating algorithm.

There are many different approaches to determine differentials for a given rating variable. The remainder of this chapter outlines traditional univariate methods that use the historical experience for each level of a rating variable in isolation to determine the differentials. Each of the approaches described assume that the rating algorithm is multiplicative, so differentials are referred to as relativities. Differentials could also be derived in an additive/subtractive fashion, though that is not addressed in this chapter's examples. The following approaches are discussed:

- Pure Premium
- Loss Ratio
- Adjusted Pure Premium

The output of these approaches is a set of indicated rate relativities. If the relativities are changed for some or all of the levels of the rating variables, this can result in more or less premium being collected overall. In most cases, the insurer will alter the base rate to compensate for the expected increase or decrease in premium. This topic, often referred to as base rate offsetting, will not be covered here but will be discussed in depth in Chapter 14.

Assumptions for Simple Example

To demonstrate each of the approaches and to highlight the pros and the cons of each, it is useful to consider a basic example.

The assumptions are as follows:

- All underwriting expenses are variable. The variable expense provision (V) is 30% of premium, and the target profit percentage (Q_T) is 5% of premium; therefore, the permissible loss ratio is 65% (= 1 – 30% - 5%).
- There are only two rating variables, amount of insurance (AOI) and territory, and the exposures are distributed across the two rating variables as follows:

9.6 Exposure Distribution

AOI	Territory 1	2	3	Total
Low	7	130	143	280
Medium	108	126	126	360
High	179	129	40	348
Total	294	385	309	988

AOI	Territory 1	2	3	Total
Low	1%	13%	14%	28%
Medium	11%	13%	13%	37%
High	18%	13%	4%	35%
Total	30%	39%	31%	100%

- The following table summarizes the true underlying loss cost relativities (which is what the actuary is attempting to estimate) as well as the relativities used currently in the company's rating structure (note that the base levels are Medium AOI and Territory 2):

9.7 True and Charged Relativities for Simple Example

AOI	True Relativity	Charged Relativity
Low	0.7300	0.8000
Medium	1.0000	1.0000
High	1.4300	1.3500

Terr	True Relativity	Charged Relativity
1	0.6312	0.6000
2	1.0000	1.0000
3	1.2365	1.3000

- The exposure, premium, and loss data for the classification analyses is summarized as follows:

9.8 Simple Example Info

AOI	Terr	Exposure	Loss & ALAE	Premium @ Current Rate Level
Low	1	7	$ 210.93	$ 335.99
Medium	1	108	$ 4,458.05	$ 6,479.87
High	1	179	$ 10,565.98	$ 14,498.71
Low	2	130	$ 6,206.12	$ 10,399.79
Medium	2	126	$ 8,239.95	$ 12,599.75
High	2	129	$ 12,063.68	$ 17,414.65
Low	3	143	$ 8,441.25	$ 14,871.70
Medium	3	126	$ 10,188.70	$ 16,379.68
High	3	40	$ 4,625.34	$ 7,019.86
TOTAL		988	$ 65,000.00	$ 100,000.00

Pure Premium Approach

Chapter 8 discussed the differences between the pure premium and loss ratio approaches in the context of developing the overall rate level indications. Those comments apply to classification ratemaking as well.

The basic pure premium approach compares the expected pure premiums for each of the levels within a rating variable to determine the indicated relativity. Given a rating variable $R1$ with the rate differential for each level i given by $R1_i$, then the rate applicable to each level of rating variable $R1$ (Rate_i) is determined as the product of the base rate (B) and the rate differential ($R1_i$):

$$\text{Rate}_i = R1_i \times B.$$

Using the subscript I to denote indicated, the indicated differential is calculated as follows:

$$R1_{\text{I},i} = \frac{\text{Rate}_{\text{I},i}}{B_{\text{I}}}.$$

Recall the formula for the indicated rate according to the pure premium method was given in Chapter 8 as:

$$\text{Indicated Rate} = \frac{\left[\overline{L + E_{\text{L}}} + \overline{E_{\text{F}}}\right]}{\left[1.0 - V - Q_{\text{T}}\right]}.$$

If all underwriting expenses are considered to be variable or if the fixed expenses are handled through a separate fee, then the fixed expense component ($\overline{E_{\text{F}}}$) is set equal to zero and the formula simplifies to the following:

$$\text{Indicated Rate} = \frac{\left[\overline{L + E_{\text{L}}}\right]}{\left[1.0 - V - Q_{\text{T}}\right]}.$$

If the fixed expenses are material and a separate expense fee is not used (i.e., the base rate includes a provision for fixed expenses), the actuary should include the fixed expense loading in the formula. By doing so, the actuary will “flatten” the otherwise indicated relativities to account for the fact that the fixed expenses represent a smaller portion of the risks with higher average premium.

Making the assumption that the fixed component is not necessary and substituting the formula for the indicated rate and base rate, the indicated differential for level i is calculated as follows:

$$R1_{\text{I},i} = \frac{\dfrac{\left[\overline{L + E_{\text{L}}}\right]_i}{\left[1.0 - V - Q_{\text{T}}\right]_i}}{\dfrac{\left[\overline{L + E_{\text{L}}}\right]_B}{\left[1.0 - V - Q_{\text{T}}\right]_B}}.$$

Based on the assumption that all policies have the same underwriting expenses and profit provisions, the formula becomes:

$$R1_{\mathrm{I},i} = \frac{\left[\overline{L + E_{\mathrm{L}}}\right]_i}{\left[\overline{L + E_{\mathrm{L}}}\right]_B}.$$

Thus, the indicated differential for a given level is equal to the projected ultimate pure premium (including LAE) for that level divided by the projected ultimate pure premium (including LAE) for the base class.

Pure Premium Approach in Practice

In practice, it is not always feasible to allocate ULAE to different classes of business, so the pure premiums used in the classification analysis generally only include loss and ALAE. Also, if the ratemaking actuary chooses to incorporate underwriting expense provisions and target profit provisions that vary by type of risk, the indicated pure premiums for each level can be adjusted by the applicable provisions prior to calculating the indicated relativities.

Depending on the nature of the portfolio, it may not always be necessary to trend and develop the loss and (A)LAE. In stable portfolios for many short-tailed lines of business (e.g., homeowners), it is often acceptable to ignore these adjustments for classification analysis. If the portfolio is growing or shrinking, or the distribution of loss and (A)LAE by class is changing over time, a multi-year pure premium analysis would be improved by applying aggregate trend and development factors to the individual year's loss and (A)LAE before summing. In certain long-tailed lines (e.g., workers compensation), it is quite possible that classes of risk undergo trend and development at materially different rates. For example, workers compensation risks with return-to-work programs may experience less development over time than risks without such a program. If trend and development are believed to be materially different by level, the actuary may want to consider developing and/or trending individual risks or levels prior to classification analysis. In addition, if the classification analysis is undertaken on losses aggregated across multiple claim types (e.g., workers compensation indemnity and medical), the actuary may choose to trend and develop the losses for each claim types separately before combining for classification analysis.

It is common to adjust losses for extraordinary and catastrophic events in classification data as they can have a disproportionate impact on a level or levels for the rating variable being analyzed. For example, a catastrophic event may only affect one territory. Similarly, one extraordinary loss only impacts one level. Consequently, the actuary should consider replacing these actual losses with an average expected figure for each level, if such data is available.

The following table shows the pure premium calculations for the simple example:

9.9 Pure Premium Method

(1) Terr	(2) Exposures	(3) Loss & ALAE	(4) Indicated Pure Premium	(5) Indicated Relativity	(6) Indicated Relativity to Base
1	294	$ 15,234.96	$ 51.82	0.7877	0.7526
2	385	$ 26,509.75	$ 68.86	1.0467	1.0000
3	309	$ 23,255.29	$ 75.26	1.1439	1.0929
Total	988	$ 65,000.00	$ 65.79	1.0000	0.9554

(4)= (3)/(2)
(5)= (4)/(Tot4)
(6)= (5)/(Base5)

Column 4 represents the indicated pure premium for each of the territories as well as overall (i.e., all territories combined). The indicated pure premiums are calculated by dividing the historical losses and ALAE by the exposures for each territory. In this simple example, trend and development have been ignored. Column 5 displays the indicated relativities, which are calculated as the pure premium for each territory divided by the total pure premium. This value represents the indicated relationship between the given territory and the total. Normally, as discussed in Chapter 2, companies select a base level for each rating variable, and all other levels for that rating variable are expressed relative to the base. In this case, the indicated relativities to the base class (assuming Territory 2 is the base territory) are determined by dividing the indicated relativity for each territory by the indicated relativity for Territory 2. This result is displayed in Column 6.

Clearly, Column 6 can be calculated directly from Column 4. The interim step was included as companies will typically compare current, indicated, and competitors' relativities all normalized so that the total average exposure-weighted relativity is 1.00 for each. By doing this, the relativities can be compared on a consistent basis. This consistent basis is also relevant when indicated relativities are credibility-weighted with other experience (as discussed in Chapter 12).

As stated, all expenses were assumed to be variable, and the variable expense and target profit provisions were assumed to apply uniformly to all risks and thereby excluded from the calculations.

Distortion

The true underlying pure premium relativities and the relativities indicated by the pure premium analysis are as follows:

9.10 Result Comparison

Terr	True Relativity	Pure Premium Indication
1	0.6312	0.7526
2	1.0000	1.0000
3	1.2365	1.0929

The indicated territorial relativities do not match the true relativities due to a shortcoming of the univariate pure premium approach. The pure premium for each level is based on the experience of each level, and assumes a uniform distribution of exposures across all other rating variables. To the extent that one territory may have a disproportionate number of exposures of high or low amount of insurance homes, this assumption is violated. By ignoring this exposure correlation between territory and amount of insurance, the loss experience of high or low amount of insurance homes can distort the indicated territorial relativities resulting in a "double counting" effect.

In the simple example, the Territory 1 indicated pure premium relativity is higher than the true relativity due to a disproportionate share of high-value homes in Territory 1. Similarly, the Territory 3 indicated pure premium relativity is lower than the true relativity due to a disproportionate share of low-value homes in Territory 3. If amount of insurance were distributed in the same way within each territory, the resulting indicated relativities from the pure premium method would not have been affected. This does not mean that each of the three amount of insurance levels needs to represent one-third of the exposures within each territory; it merely implies that the distribution of amount of insurance must be the same within every territory.

This example only has two rating variables. In reality, there are many different characteristics that affect the risk potential for each insured. To the extent there is a distributional bias in some or all of the other characteristics, the resulting pure premiums can be materially biased.

Loss Ratio Approach

The major difference between the pure premium and loss ratio approaches is that the loss ratio approach uses premium as opposed to exposure. The basic loss ratio approach compares the loss ratios for each of the levels to the total loss ratio in order to determine the appropriate adjustment to the current relativities.

Start with the pure premium indicated differential formula (which assumes all policies have the same underwriting expenses and profit provisions):

$$R1_{\mathrm{I},i} = \frac{\left[\overline{L+E_{\mathrm{L}}}\right]_i}{\left[\overline{L+E_{\mathrm{L}}}\right]_B} = \frac{\dfrac{(L+E_{\mathrm{L}})_i}{X_i}}{\dfrac{(L+E_{\mathrm{L}})_B}{X_B}}.$$

Multiplying both sides of the equation by the ratio of the average premium at current rates for the base level ($\overline{P_{\mathrm{C},B}}$) to the average premium at current rates for level *i* of the rating variable being reviewed ($\overline{P_{\mathrm{C},i}}$):

$$R1_{\mathrm{I},i} \times \frac{\overline{P_{\mathrm{C},B}}}{\overline{P_{\mathrm{C},i}}} = \frac{\left[\overline{L+E_{\mathrm{L}}}\right]_i}{\left[\overline{L+E_{\mathrm{L}}}\right]_B} \times \frac{\overline{P_{\mathrm{C},B}}}{\overline{P_{\mathrm{C},i}}}.$$

Recognizing that average premium is equal to total premium divided by total exposures and that the pure premium is equal to the total losses and LAE divided by total exposures:

$$\overline{P} = \frac{P}{X} \quad \text{and} \quad \overline{L + E_L} = \frac{L + E_L}{X},$$

and that the current differential for level i ($R1_{C,i}$) is equal to the ratio of the current average premium for level i divided by the current average premium at the base level:

$$R1_{C,i} = \frac{\overline{P_{C,i}}}{\overline{P_{C,B}}},$$

the above formula can be transformed:

$$\text{Indicated Differential Change} = \frac{R1_{I,i}}{R1_{C,i}} = \frac{\dfrac{(L+E_L)_i}{P_{C,i}}}{\dfrac{(L+E_L)_B}{P_{C,B}}} = \frac{\text{Loss \& LAE Ratio for } i}{\text{Loss \& LAE Ratio for } B}.$$

Loss Ratio Approach in Practice

Similar to the pure premium approach, many of the same data limitations and assumptions regarding losses apply (e.g., ULAE cannot be allocated by class). In the loss ratio approach, however, it is important to bring earned premium to the current rate level of each class. This is most accurately done via extension of exposures, though the parallelogram method can be performed at the class level if data limitations preclude use of extension of exposures.

The following table shows the calculations for the simple example:

9.11 Loss Ratio Method

(1) Terr	(2) Premium @ Current Rate Level	(3) Loss & ALAE	(4) Loss & ALAE Ratio	(5) Indicated Relativity Change Factor	(6) Current Relativity	(7) Indicated Relativity	(8) Indicated Relativity @Base
1	$ 21,314.57	$ 15,234.96	71.5%	1.1000	0.6000	0.6600	0.6540
2	$ 40,414.19	$ 26,509.75	65.6%	1.0092	1.0000	1.0092	1.0000
3	$ 38,271.24	$ 23,255.29	60.8%	0.9354	1.3000	1.2160	1.2049
Total	$ 100,000.00	$ 65,000.00	65.0%	1.0000			

(4)= (3)/(2)
(5)= (4)/(Tot4)
(7)= (5)x(6)
(8)= (7)/(Base7)

Column 4 displays the loss and ALAE ratio for each territory and in total, which is simply the losses and ALAE divided by the premium at current rate level. Column 5 is the indicated relativity change factor, which is the loss and ALAE ratio for each territory divided by the total loss and ALAE ratio. This figure represents the amount the territory relativities should be changed to make the loss and ALAE ratios for every territory equivalent. Column 7 displays the indicated relativity for each territory, which is the product of the current relativity and the indicated change factor. The relativities in this column have the same overall weighted average as the current relativities. As discussed in the pure premium approach, it is sometimes useful to compare the current, indicated, and competitors' relativities for a variable. In such cases, each set of relativities should be adjusted so that the overall weighted-average relativity is the same. The proper weight for making this adjustment is the premium adjusted to the base class for the variable being analyzed (i.e., the premium divided by the current relativity for that variable). Column 8 adjusts the relativities to the base level by dividing the indicated relativity for each level by the indicated relativity at the base level.

Distortion

The true underlying relativities and the indicated relativities from both the pure premium and loss ratio methods are as follows:

9.12 Result Comparison

Terr	True Relativity	Pure Premium Indication	Loss Ratio Indication
1	0.6312	0.7526	0.6540
2	1.0000	1.0000	1.0000
3	1.2365	1.0929	1.2049

While the indicated territorial relativities from the loss ratio method do not match the true relativities, they are closer than those calculated using the pure premium approach. Since the pure premium approach relies on exposures (i.e., one exposure for each house year), the risks in each territory are treated the same regardless of the amount of insurance. In contrast, the use of premium in the denominator of the loss ratio reflects the fact that the insurer collects more premium for homes with higher amounts of insurance. Using the current premium helps adjust for the distributional bias. Even so, the loss ratio method still did not produce the correct relativities. The remaining distortion reflects the variation for the amount of insurance relativities being charged rather than the true variation. If the current amount of insurance relativities are equivalent to the true amount of insurance relativities, then the loss ratio method will produce the true territorial relativities.

An important yet subtle point is that the indicated relativities for a given rating variable produced using the loss ratio method "adjust" for the inequity present in the other rating variables. In the example, the rate relativity for Territory 1 developed using the loss ratio method is higher than the true relativity because the process by which it takes into account the high proportion of high-valued homes relies on the current amount of insurance relativities that are under-priced. The downside to this adjustment is that all homes in Territory 1, not just the high-value homes, are being charged an extra amount to correct for the inequity in amount of insurance relativities.

Adjusted Pure Premium Approach

The loss ratio approach requires the actuary to obtain premium at current rate level for each level of the variable being analyzed. In some cases it may not be practical to obtain premium at that level of refinement; consequently, it will be necessary to use the pure premium approach rather than the loss ratio approach. In such cases, it is possible to make an adjustment to the pure premium approach to minimize the impact of any distributional bias.

As discussed in the previous section, using premium in the loss ratio approach helps adjust for the distributional bias that distorts the pure premium approach. To make the results of the two approaches more consistent, the pure premium approach can be performed using exposures adjusted by the exposure-weighted average relativity of all other variables.

The following table shows the calculation of the current exposure-weighted average amount of insurance relativities by territory.

9.13 Weighted AOI Relativity

AOI	Charged AOI Factor	Exposures by Territory 1	2	3
Low	0.8000	7	130	143
Medium	1.0000	108	126	126
High	1.3500	179	129	40
Total		294	385	309
Wtd Avg AOI Relativity by Terr		1.2083	1.0497	0.9528

If there are multiple rating variables, then the table above needs to be expanded so that the exposure-weighted average relativity is based on all rating variables. Often, a rating algorithm can include too many variables to make this a practical exercise. In such cases, the actuary may focus only on rating variables suspected to have a distributional bias across the levels of the rating variable being analyzed.

The following shows the pure premium calculation using the adjusted exposures.

9.14 Adjusted Pure Premium Method

(1) Terr	(2) Earned Exposures	(3) Wtd Avg AOI Relativity	(4) Adjusted Exposures	(5) Loss & ALAE	(6) Indicated Adjusted Pure Premium	(7) Indicated Relativity	(8) Indicated Relativity @Base
1	294	1.2083	355.24	$ 15,234.96	$ 42.89	0.6954	0.6538
2	385	1.0497	404.13	$ 26,509.75	$ 65.60	1.0636	1.0000
3	309	0.9528	294.42	$ 23,255.29	$ 78.99	1.2806	1.2040
Total	988		1,053.79	$ 65,000.00	$ 61.68	1.0000	0.9402

(3)= from Table 9.13
(4)= (2)x(3)
(6)= (5)/(4)
(7)= (6)/(Tot6)
(8)= (7)/(Base7)

Distortion

Since the current amount of insurance relativities were used for the adjustment, the resulting indicated relativities are equivalent to those calculated using the loss ratio approach (except for rounding), and the same comments made about the distortion associated with the loss ratio approach apply.

If the true amount of insurance relativities are used to determine the exposure-weighted average relativity, then the indicated territorial relativities will be correct. Of course, the true relativities are not known for each rating variable. If they were, no analysis would be necessary.

WORKSHEET EXAMPLE

Appendix E shows a full set of example calculations for the pure premium and loss ratio classification approaches.

SUMMARY

If companies want to compete effectively over the long term, it is critical that their rates are appropriate in the aggregate and at the individual risk level. If a company fails to charge appropriate rates at the individual risk level when other companies are doing so, their lower-risk insureds are likely to leave and insure with other companies that are charging lower rates. If not addressed, the company can be subjected to adverse selection.

For most lines of business, it is not feasible to set rates on a risk-by-risk basis, so companies attempt to identify characteristics that can be used as rating variables to subdivide the insured population into more homogeneous, but still credible, groups for the purposes of rating. Companies should consider statistical, operational, and social criteria, and review applicable laws and statutes when deciding whether or not to use a certain characteristic as a rating variable.

Once the company determines the risk characteristics that will be used as rating variables, the company can perform univariate pure premium, loss ratio, or adjusted pure premium analysis to determine the indicated differentials for each level of each rating variable. These techniques often cause distortions; consequently, many companies have moved to multivariate techniques, which are feasible with today's technology. The fundamental principles of multivariate techniques are covered in the next chapter. Some companies still use these univariate techniques and make adjustments to account for the known distortions.

KEY CONCEPTS IN CHAPTER 9

1. Definitions used in classification ratemaking
    a. Rating variable
    b. Level of a rating variable
    c. Rate differentials

2. Importance of equitable rates
    a. Adverse selection
    b. Favorable selection

3. Considerations for evaluating rating variables
    a. Statistical criteria
    b. Operational criteria
    c. Social criteria
    d. Legal criteria

4. Calculating indicated rate differentials
    a. Pure premium approach
    b. Loss ratio approach
    c. Adjusted pure premium approach

CHAPTER 10: MULTIVARIATE CLASSIFICATION

As discussed in the previous chapter, classification ratemaking allows the insurer to price individual risks more equitably by analyzing the loss experience of groups of similar risks. This protects the insurer against adverse selection, which can lead to unsatisfactory profits and loss in market share. Effective classification ratemaking may provide insurers with a competitive advantage and may help expand the profile of risks the insurer is willing and able to write profitably.

This chapter begins with a review of the shortcomings of the one-way classification ratemaking approaches outlined in the previous chapter. It then discusses the advancement of iteratively standardized one-way approaches, such as the minimum bias procedures, which address some of the shortcomings of one-way approaches. Much of this chapter is dedicated to the use of multivariate approaches, including:

- Circumstances that led to their adoption in classification ratemaking
- The overall benefits of multivariate approaches
- A basic explanation of the mathematical foundation of one particular multivariate method, generalized linear models (GLMs)
- A sample of GLM output
- Examples of statistical diagnostics associated with GLMs

Finally, this chapter concludes with a brief discussion of practical considerations and two developments that have augmented multivariate analysis in the context of classification ratemaking: data mining techniques and the use of external data sources.

A REVIEW OF THE SHORTCOMINGS OF UNIVARIATE METHODS

The previous chapter reviewed one-way, or univariate, approaches to classification ratemaking whereby the loss experience (either pure premium or loss ratio) of the levels within each rating variable is examined and compared in order to establish rate differentials to the base level.

The shortcomings of univariate approaches were also discussed—the primary one being that they do not accurately take into account the effect of other rating variables. The pure premium approach does not consider exposure correlations with other rating variables. If the rating algorithm only contained a handful of rating variables, this shortcoming could be mitigated with two-way analysis or some manual adjustments. Today, however, actuaries working on many lines of business are analyzing tens or hundreds of variables that make manual adjustment inefficient if not impossible.

As an illustrative example of the distortion created with univariate methods, a one-way pure premium analysis may show for a personal auto insurance book of business that older cars have high claims experience relative to newer cars. In reality, however, this analysis is distorted by the fact that older cars tend to be driven by younger drivers—who tend to have high claims experience. The experience for both young drivers and old cars looks unfavorable despite the fact that this may be driven primarily by the youthful driver effect.

Conducting a loss ratio analysis adjusts for an uneven mix of business to the extent the premium varies with risk, but current premium is only an approximation as it most often deviates from true loss cost differentials. Similarly, the adjusted pure premium approach attempts to standardize data for the uneven mix of business by multiplying exposures by the exposure-weighted average of all other rating variables' relativities before calculating the one-way relativities. Again, this is merely an approximation to a proper reflection of all exposure correlations.

MINIMUM BIAS PROCEDURES

Another classification ratemaking approach that was popular during the latter half of the 20th century is the family of minimum bias procedures. Essentially these are iteratively standardized univariate approaches. Each procedure involves the selection of a rating structure (e.g., additive, multiplicative or combined) and the selection of a bias function (e.g., balance principle, least squares, χ^2, and maximum likelihood bias functions). The bias function is a means of comparing the procedure's observed loss statistics (e.g., loss costs) to indicated loss statistics and measuring the mismatch. Both sides of this equation must be weighted by the exposures in each cell to adjust for an uneven mix of business. The term "minimum bias" refers to the commonly used balance principle that requires that the sum of the indicated weighted pure premiums equals the sum of the weighted observed loss costs for every level of every rating variable. This is referred to as "minimizing the bias" along the dimensions of the classification system.

A simple example of the balance principle applied to a multiplicative personal auto rating structure is outlined below. This example assumes only two rating variables: gender and territory. Gender has values male (with a rate relativity expressed as g_1) and female (g_2). Territory has values urban (t_1) and rural (t_2). The base levels, relative to which all multiplicative indications will be expressed, are female and rural (hence g_2 = 1.00 and t_2 = 1.00). The actual loss costs (or pure premiums) are as follows:

	Urban	Rural	Total
Male	\$650	\$300	\$528
Female	\$250	\$240	\$244
Total	\$497	\$267	\$400

The exposure distribution is as follows:

	Urban	Rural	Total
Male	170	90	260
Female	105	110	215
Total	275	200	475

As stated previously, the balance principle requires that the exposure-weighted observed loss costs equal the indicated exposure-weighted loss cost across every dimension of each rating variable (i.e., each gender and each territory). The following four equations show the observed weighted loss costs on the left and the indicated weighted loss costs (represented as the product of the base rate, the exposure, and the indicated relativities) on the right. The base rate is assumed to be \$100.

Males	170 x \$650 + 90 x \$300 = \$100 x 170 x g_1 x t_1 + \$100 x 90 x g_1 x t_2.
Females	105 x \$250 + 110 x \$240 = \$100 x 105 x g_2 x t_1 + \$100 x 110 x g_2 x t_2.
Urban	170 x \$650 + 105 x \$250 = \$100 x 170 x g_1 x t_1 + \$100 x 105 x g_2 x t_1.
Rural	90 x \$300 + 110 x \$240 = \$100 x 90 x g_1 x t_2 + \$100 x 110 x g_2 x t_2.

The next step is to choose initial, or seed, relativities for the levels of one of the rating variables.

Generally a sensible seed is the univariate pure premium relativities. Hence, the urban relativity is the total urban loss costs divided by the total rural loss costs:

t_1 = 1.86 = (\$497 / \$267)

t_2 = 1.00.

Substituting these seed values into the first two equations above, we are able to solve for the first values of g_1 and g_2:

170 x \$650 + 90 x \$300 = (\$100 x 170 x g_1 x 1.86) + (\$100 x 90 x g_1 x 1.00)

\$137,500 = (\$31,620 x g_1) + (\$9,000 x g_1)

\$137,500 = \$40,620 x g_1

g_1 = 3.39.

105 x \$250 + 110 x \$240 = (\$100 x 105 x g_2 x 1.86) + (\$100 x 110 x g_2 x 1.00)

\$52,650 = (\$19,530 x g_2) + (\$11,000 x g_2)

\$52,650 = \$30,530 x g_2

g_2 = 1.72.

We can now use these seed values for gender, g_1 and g_2, and set up equations to solve for the new intermediate values of t_1 and t_2:

170 x \$650 + 105 x \$250 = (\$100 x 170 x 3.39 x t_1) + (\$100 x 105 x 1.72 x t_1)

\$136,750 = (\$57,630 x t_1) + (18,060 x t_1)

\$136,750 = \$75,690 x t_1

t_1 = 1.81.

$90 \text{ x } \$300 + 110 \text{ x } \$240 = (\$100 \text{ x } 90 \text{ x } 3.39 \text{ x } t_2) + (\$100 \text{ x } 110 \text{ x } 1.72 \text{ x } t_2)$

$\$53{,}400 = (\$30{,}510 \text{ x } t_2) + (\$18{,}920 \text{ x } t_2)$

$\$53{,}400 = \$49{,}430 \text{ x } t_2$

$t_2 = 1.08$.

This same procedure is repeated, each time discarding the previous relativities and solving for new ones. The procedure is iterated until there is no material change in any of the values of g_1, g_2, t_1, and t_2. Upon such convergence, it is common practice to normalize the base class relativities to 1.00. For example, assume the relativities derived above represent the final iteration. Normalizing the base class relativities to 1.00 would result in:

$g_1 = 3.39 / 1.72 = 1.97$

$g_2 = 1.72 / 1.72 = 1.00$

$t_1 = 1.81 / 1.08 = 1.68$

$t_2 = 1.08 / 1.08 = 1.00$.

Recall from above that the univariate relativity for t_1 was 1.86 (this was used to seed the initial value of t_1 in the minimum bias equations). After one iteration of the minimum bias method, the replacement value for t_1 is 1.68. The minimum bias result reflects the fact that the cell for urban males has considerably more exposure than the other cells; consequently, the experience in that cell is given more weight.

Finally, the base loss cost also needs to be adjusted to reflect the normalization:

Base loss cost = \$100 x 1.72 x 1.08 = \$185.76.

Now the reader should better understand the phrase iteratively standardized one-ways. The method outlined above involves performing several iterations of univariate analysis on rating variables, each time adjusting for the exposure weight and the indication of the previous variable in the sequence. Note that the simple example outlined above only considers one of the minimum bias methods (multiplicative structure with balance principle) using the pure premium statistic. In addition, it considers only two rating variables each with two levels. The computation required to incorporate several rating variables requires at the very least some spreadsheet programming. Several papers have been authored on the various minimum bias procedures. Detailed, intuitive explanations with simple illustrative examples are contained in “The Minimum Bias Procedures: A Practitioner’s Guide” (Feldblum and Brosius 2002, pp. 591-684). Sequential analysis, a method related to minimum bias, may also be of interest to the ratemaking actuary. It is currently mandated as the only classification ratemaking method allowed for pricing voluntary private passenger automobile insurance in the state of California. In sequential analysis, the actuary performs a standard one-way analysis on the first variable selected to determine the indicated relativities. The exposures are adjusted for the results of the first variable’s analysis (i.e., the adjusted one-way pure premium approach), and the indicated relativities are calculated for the second variable. This continues until the actuary has calculated the indicated relativities for every variable. Sequential analysis involves making only one pass through the sequence of chosen rating variables (rather than iterating until convergence is achieved). The main criticism of the non-iterative sequential approach is that it does not have a closed form solution; the results vary depending on the order of the rating variables in the sequence. There is considerably more detail to the sequential analysis mandated in California, and the ratemaking actuary should seek additional references if working in that market.

THE ADOPTION OF MULTIVARIATE METHODS

The minimum bias procedures are not technically multivariate methods, and they were not necessarily based directly on statistical theory. However, many of the minimum bias procedures are actually a subset of the statistical method, generalized linear models (GLMs). In fact, iterating the minimum bias procedure a sufficient number of times may result in convergence with GLM results, though many would argue the minimum bias procedures involve less computational efficiency. Stephen Mildenhall's paper, "A Systematic Relationship between Minimum Bias and Generalized Linear Models" (Mildenhall 1999) demonstrates that many of the minimum bias procedures correspond directly to generalized linear models.

Several things happened around the late 20th century and start of the 21st century that led to the adoption of statistical techniques, particularly generalized linear models, for classification ratemaking. First, computing power greatly increased. Data no longer had to be aggregated in order to be analyzed. What previously was only achievable by large mainframe machines was now being accomplished by desktop PCs in a fraction of the time. Second, insurers were instituting data warehouse initiatives that greatly improved the granularity and accessibility of data that could be analyzed for ratemaking purposes. So despite the fact that sophisticated statistical techniques existed much earlier than this, it was the circumstances of enhanced computing power and better data that enabled their usage in classification ratemaking. A final and perhaps the most important trigger in the widespread adoption of multivariate methods was competitive pressure. As explained in the last chapter, when one or more companies implement improved classification ratemaking, they gain a competitive advantage and put the rest of the industry in a position of adverse selection and decreased profitability. This occurred in the U.K. personal lines markets in the 1990s and in the U.S. personal auto markets in the early 2000s.

THE BENEFITS OF MULTIVARIATE METHODS

The main benefit of multivariate methods is that they consider all rating variables simultaneously and automatically adjust for exposure correlations between rating variables, which should now be understood as the primary shortcoming of univariate approaches. Later in this chapter a graphical example (Figure 10.1) shows a disparity in results between the univariate method and a particular multivariate method, when rating variables are correlated.

Secondly, multivariate methods attempt to remove unsystematic effects in the data (also known as noise) and capture only the systematic effects (also known as signal) as much as possible. This is not the case with univariate methods, which include both signal and noise in the results.

Third, many multivariate methods produce model diagnostics, additional information about the certainty of results and the appropriateness of the model fitted. Statistical assumptions and model diagnostics will be discussed in more detail later in this chapter.

A fourth benefit of multivariate methods is that they allow consideration of the interaction, or interdependency, between two or more rating variables. Interactions occur when the effect of one variable varies according to the levels of another (e.g., the effect of square footage varies across different levels of amount of insurance). Interactions are an important refinement to multivariate models that can improve the predictive value. They also complicate the model and should therefore be analyzed with an eye for business considerations (e.g., ease of understanding and monitoring results).

As a side note, it is important not to confuse interaction (sometimes referred to as response correlation) with exposure correlation, which describes a relationship between the exposures of one rating variable and another. Gender exposures may be uniformly distributed across age (meaning at any age there is an identical distribution of men and women and no exposure correlation exists), but the two variables may interact if the loss experience for men relative to women is distinctly different at the youthful ages than at the middle and senior ages. Conversely, a variable's exposures may be unevenly distributed across the levels of another rating variable (i.e., exposure correlation exists), yet no interaction is present. The other scenarios of both exposure correlation and interaction being present or neither being present are less confusing.

Other potential benefits vary considerably among the different types of multivariate methods. For example, GLMs, which will be discussed later in this chapter, are widely accepted as a classification ratemaking method. One of the main advantages of GLMs is that they are transparent; the model output includes parameter estimates for each level of each explanatory variable in the model, as well as a range of statistical diagnostics. Other multivariate techniques, such as neural networks (also discussed briefly later in this chapter) are often criticized for a lack of transparency. No matter how sophisticated the mathematics underlying a method, it is important for practitioners to be able to follow and communicate how the results were developed and be able to translate the results into something that can be implemented in the insurance company's operations.

So how do the methods mentioned thus far stack up to this list of benefits? As discussed, the results of univariate approaches are distorted by distributional biases. The results can also be heavily distorted by unsystematic effects (noise). The result is a set of answers with no additional information about the certainty of the results. Interactions can be incorporated but only by expanding the analysis into two-way or three-way tables. Perhaps it scores high only in terms of transparency, but this is overshadowed by the inaccuracies of the method.

In contrast, the minimum bias methods account for an uneven mix of business but, as stated previously, the iterative calculations are considered computationally inefficient. As with one-way analysis, no diagnostics are included. This method scores high on transparency and outperforms univariate analysis in terms of accuracy, but does not provide all of the benefits of full multivariate methods.

GLMs

The multivariate statistical technique that has quickly become the standard for classification ratemaking in many countries and for many lines of business is the generalized linear model, GLM. This technique achieves each of the benefits of multivariate methods listed above. Though less transparent than the cruder and less accurate univariate results, it still scores favorably in comparison to other multivariate methods such as neural networks. Not only can the iterations of a GLM be tracked, but the output of a multiplicative GLM is a series of multipliers—much like the insurance industry is accustomed to using in rating algorithms and rating manuals.

A Mathematical Foundation for GLMs: Linear Models

Though touted above as a relatively transparent method, many practitioners familiar with the traditional univariate approaches may not understand the statistical underpinnings of GLMs. A good foundation for understanding GLMs is to first review linear models (LMs), something many actuaries may have studied in college coursework. Both LMs and GLMs aim to express the relationship between an observed response variable (Y) and a number of explanatory variables, referred to as predictor variables. For example, the response variable may be claim frequency for homeowners insurance, and the predictor variables may include amount of insurance, age of home, and deductible. The observations in the data (e.g., claims on individual exposures) are considered a realization of the response variable.

Linear models express the response variable (Y) as the sum of its mean (μ) and a random variable (ε), also known as the error term:

$$Y = \mu + \varepsilon.$$

They assume that the mean can be written as a linear combination of the predictor variables. For example,

$$Y = (\beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4) + \varepsilon,$$

where X_1, X_2, X_3, and X_4 are each predictor variables, and β_1, β_2, β_3, and β_4 are the parameter estimates to be derived by the LM.

Linear models also assume that the random variable, ε, is normally distributed with a mean of zero and constant variance, σ^2.

The aim of the linear model is to find the parameter estimates, which, when applied to the chosen model form, produce the observed data with the highest probability. The function used to achieve this aim is usually the likelihood function (or equivalently the log-likelihood). Maximum likelihood relies on linear algebra to solve a system of equations. In practice, due to the high volume of observations in classification ratemaking datasets, numerical techniques such as multi-dimensional Newton-Raphson algorithms are employed. These techniques find the maximum of a function by finding a zero in the function's first derivative. Also note that in the specific case of linear models, the likelihood function is equivalent to minimizing the sum of squared error between actual and indicated.

Generalized Linear Models: Loosening the Restrictions

GLMs are a generalized version of linear models that remove the restrictions of the normality assumption and the constant variance. They also allow a function, called the link function, to define the relationship between the expected response variable (e.g., claim severity) and the linear combination of the predictor variables (e.g., age of home, amount of insurance, etc.). The choice of various link functions means the predictor variables do not have to relate strictly in an additive fashion (as they do with LMs). For example, GLMs fit to insurance claims experience for ratemaking purposes often specify a log link function, which assumes the rating variables relate multiplicatively to one another. There are other components of the GLM formularization (offset terms, prior weights) that are beyond the scope of this text.

In order to solve a GLM, the modeler must:

- Supply a modeling dataset with a suitable number of observations of the response variable and associated predictor variables to be considered for modeling.
- Select a link function to define the relationship between the systematic and random components.
- Specify the distribution of the underlying random process, typically a member of the exponential family of distributions (e.g., normal, Poisson, gamma, binomial, inverse Gaussian[33]); this is done by specifying the mean and the variance of the distribution, the latter being a function of the mean.

The maximum likelihood approach then maximizes the logarithm of the likelihood function and computes the predicted values for each variable.

More comprehensive detail on the theory of GLMs is beyond the scope of this text, but may be found in Section 1 of "The Practitioner's Guide to Generalized Linear Models" (Anderson , D. et al. 2005).

SAMPLE GLM OUTPUT

Unlike univariate analysis of claims experience that is typically performed on either loss ratios or loss costs, GLM analysis is typically performed on loss cost data (or preferably frequency and severity separately). There are statistical and practical reasons supporting this practice:

- Modeling loss ratios requires premiums to be adjusted to current rate level at the granular level and that can be practically difficult.
- Experienced actuaries have an a priori expectation of frequency and severity patterns (e.g., youthful drivers have higher frequencies). In contrast, the loss ratio patterns are dependent on the current rates. Thus, the actuary can better distinguish the signal from the noise when building models.
- Loss ratio models become obsolete when rates and rating structures are changed.
- There is no commonly accepted distribution for modeling loss ratios.

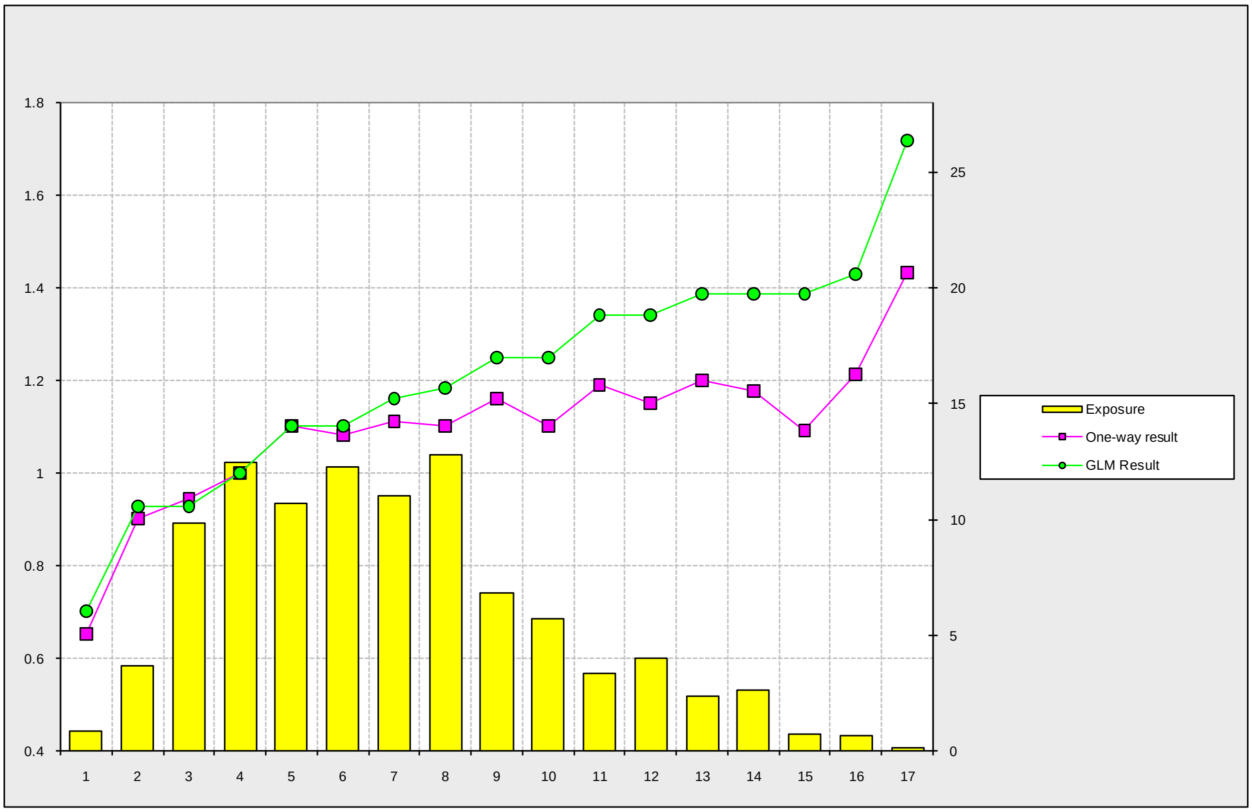
More details can be found about this in "GLM Basic Modeling: Avoiding Predictive Modeling Pitfalls" (Werner and Guven 2007, pp. 263-264). Best practice also dictates that modeling be performed on a homogeneous body of claims. For example, personal automobile models are generally performed at the

[33] The Tweedie family of distributions is considered a special extension of the exponential family.

coverage level but could even be more granular (e.g., subdividing comprehensive claims into theft and non-theft).

A useful way to strengthen an understanding of GLMs is to view illustrative graphical output. The following graph shows the effect of the rating variable vehicle symbol on claim frequency for the claim type personal auto collision. This rating variable has seventeen discrete levels, and each level's exposure count is represented by the yellow bars (the right y-axis). Each symbol represents a group of vehicles that have been combined based on common characteristics (e.g., weight, number of cylinders, horsepower, cost). Note that in addition to discrete variables (also known as categorical factors), GLMs can also accommodate numeric fields as continuous variables (referred to as variates). Variates can take the form of polynomials or splines[34] within GLMs.

10.1 Effect of Vehicle Symbol on Automobile Collision Frequency



This output is from a multiplicative model. The base level, to which all other levels' parameter estimates will be expressed relative, is vehicle symbol 4. Consequently, its multiplicative differential is 1.00. The base level is typically chosen as one with a fairly large, if not the largest, volume of exposure. This ensures statistical diagnostics are expressed relative to something large and presumably stable. The GLM output is shown as the green line with circle markers. The GLM gives the statistical effect of vehicle symbol on collision frequency, all other variables being considered. For example, the GLM indicates that vehicle symbol 10 has a 25% higher indicated collision frequency than vehicle symbol 4, all other

[34] Splines are a series of polynomial functions with each function defined over a short interval.

variables being considered. The pink line with the square markers on the graph represents the results of a univariate analysis. The disparity suggests vehicle symbol is strongly correlated with another variable in the model (perhaps age of driver, prior accident experience, or some other variable), and the univariate results are distorted as discussed earlier.

In a multivariate analysis, it is important to understand the phrase "all other variables being considered."[35] The GLM results of one variable are only meaningful if the results for all other variables are considered at the same time. So for example, the indicated relativity for vehicle symbol 10 discussed above will not be valid if the model is manipulated to remove or change other key predictor variables in the model. Consequently, the results of one variable are only valid if the results for all other key variables are also being used. In other words, that indicated relativity for vehicle symbol 10 is dependent on the other relativities being considered. Chapter 13 discusses how the company's final rate relativities often deviate from the actuary's indicated relativities for business reasons, but for now it is important to understand the statistical relevance of the comments above.

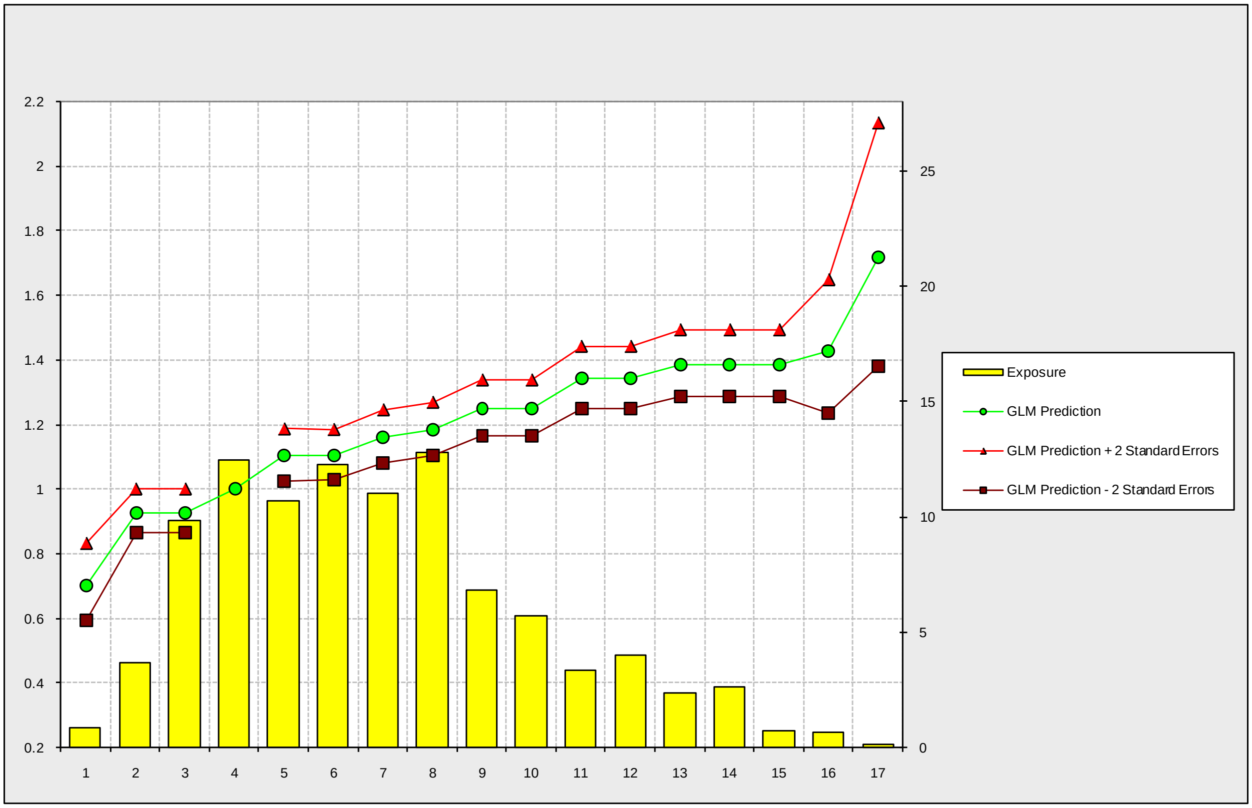
A SAMPLE OF GLM DIAGNOSTICS

Chapter 9 listed statistical significance as an important criterion for evaluating the appropriateness of rating variables. A previous section of this chapter listed the statistical diagnostics to be a major benefit of GLMs. These are tools that aid the modeler in understanding the certainty of the results and the appropriateness of the model. Certain diagnostics can help determine if a predictive variable has a systematic effect on insurance losses (and should therefore be retained in the model). Models should be refined until only such significant variables remain. Other diagnostics assess the modeler's assumptions around the link function and error term. Diagnostics can be grounded in statistical theory or can be more practical in nature. Examples of each will be given.

One of the most common statistical diagnostics for deciding whether a variable has a systematic effect on losses is the standard errors calculation. The mathematical concept is beyond the scope of this text, but "The Practitioner's Guide to Generalized Linear Models" supplies a nice intuitive explanation: "standard errors are an indicator of the speed with which the log-likelihood falls from the maximum given a change in parameter." Two standard errors from the parameter estimates are akin to a 95% confidence interval. This means the GLM parameter estimate is a point estimate, and the standard errors show the range in which the modeler can be 95% confident the true answer lies within. The following graph is identical to the graph shown previously for vehicle symbol but now includes standard error lines for the non-base levels (i.e., +/- two standard errors from the differentials indicated by the GLM). In this particular case, the upward pattern and narrow standard errors suggest this variable is statistically significant. Wide standard errors, often straddling unity, might suggest the factor is detecting mostly noise and is worthy of elimination from the model. In this example, symbol 17 shows wide standard errors, but that is mainly a function of the small volume present in that level. It does not invalidate the strong results for symbols 1-16, where most of the business volume exists.

[35] This caveat may also be written as "all other variables being constant" or "all other variables at the base level."

10.2 Standard Errors for Effect of Vehicle Symbol on Automobile Collision Frequency

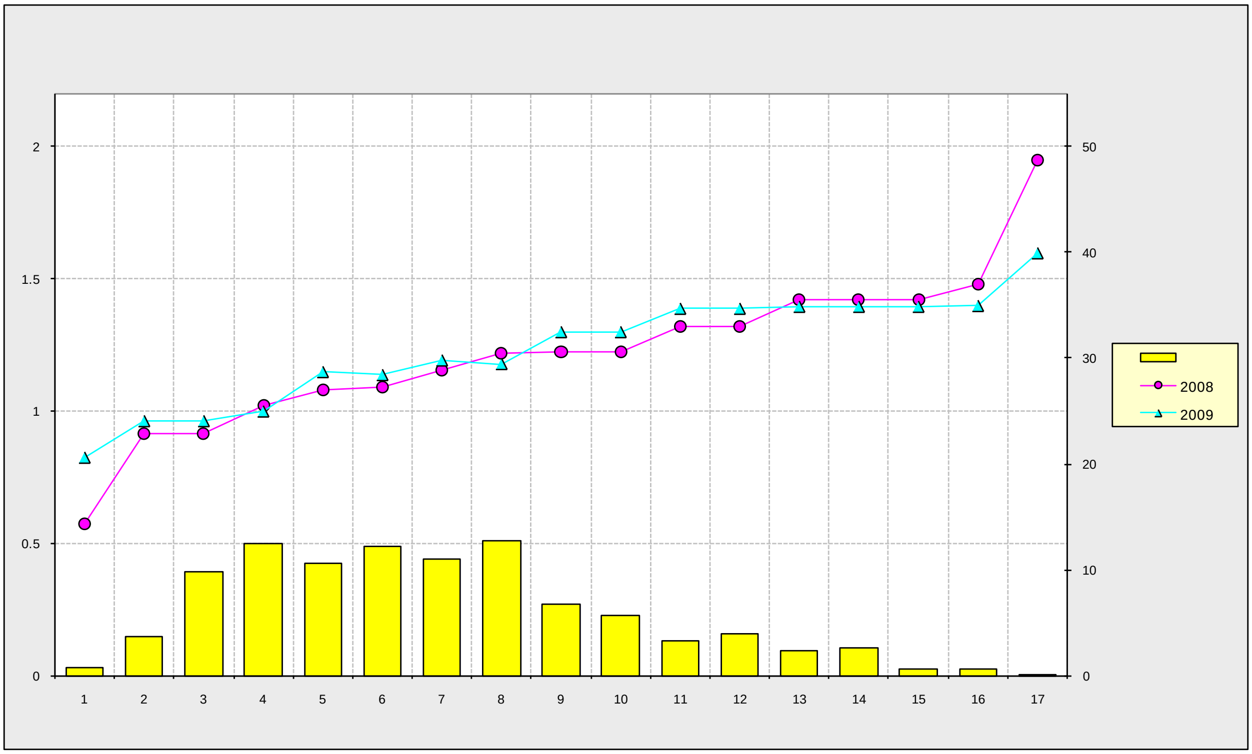


Measures of deviance are an additional diagnostic to assess the statistical significance of a predictor variable. Generally speaking, a deviance is a single figure measure of how much the fitted values differ from the observations. Deviance tests are often used when comparing nested models (one is a subset of the other) to assess whether the additional variable(s) in the broader model are worth including. The deviance of each model is scaled and the results are compared. Statistical tests such as Chi-Square or F-test are used to gauge the theoretical trade-off between the gain in accuracy by adding the variables versus the loss of parsimony in adding more parameter estimates to be solved. Similarly, deviance tests such as Akaike Information Criteria (AIC) and BIC (Bayesian Information Criteria) can be applied to non-nested models.

An example of a practical diagnostic in the modeling process is comparing the GLM results for individual years (assuming a multi-year dataset) to gauge consistency of results from one year to the next.[36] The following graph shows the effect of vehicle symbol on automobile collision frequency separately for the two years present in the experience period. The two lines show some random differences but in general the patterns are the same.

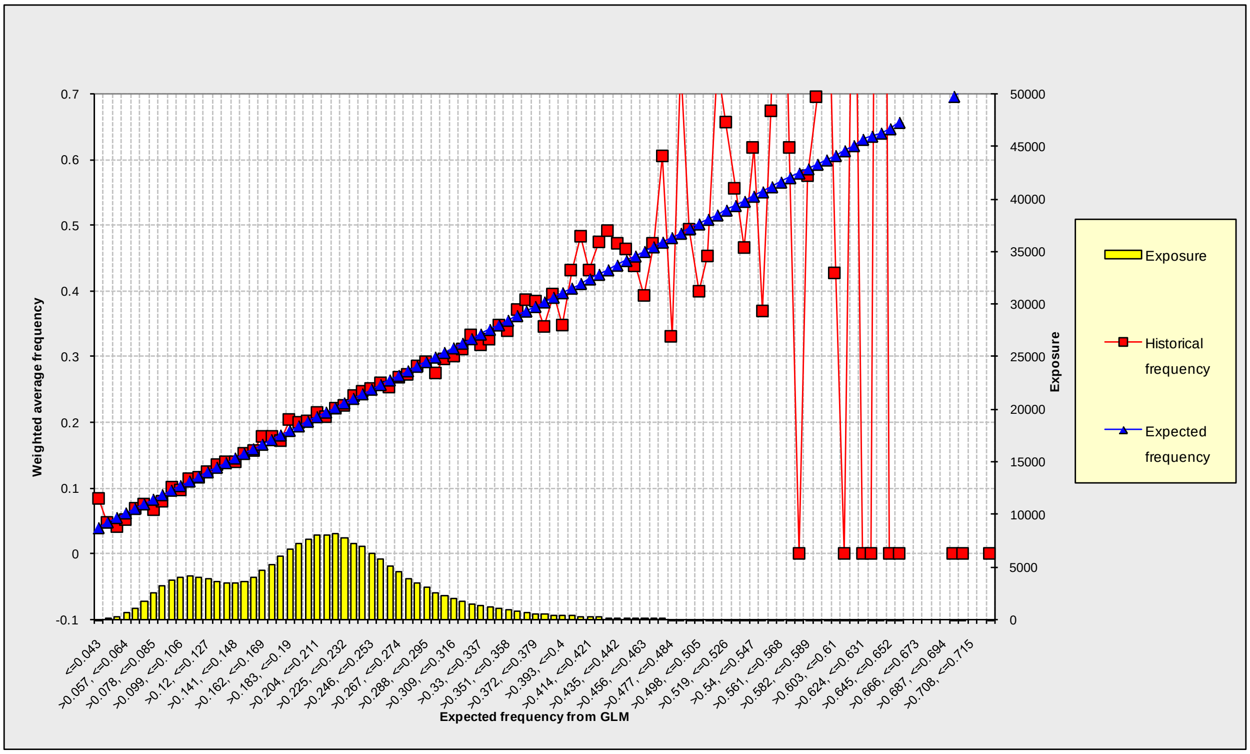
[36] Consistency can also be tested on random subsets of data rather than individual years.

10.3 Consistency of Time for Vehicle Symbol



In addition to reviewing these diagnostics for each factor, another best practice is to perform model validation techniques. One such technique compares the expected outcome of the model with historical results on a hold-out sample of data (i.e., data that was not used in the development of the model so that it could be used to test the effectiveness of the model). The extent to which the model results track closely to historical results for a large part of the portfolio is an indication of how well the model validates. The following example output is a validation of a frequency model. For most of the sample, the bands of expected frequencies from the GLM (ordered from lowest to highest) track very closely to the actual weighted frequency of each band in the hold-out sample of data. The volatile results for the high expected frequency bands are a result of low volume of data.

10.4 Model Validation



Considerable disparity between actual and expected results on the hold-out sample may indicate that the model is over or under-fitting. If the modeler retains variables in the model that reflect a non-systematic effect on the response variable (i.e., noise) or over-specifies the model with high order polynomials, the result is over-fitting. Such a model will replicate the historical data very well (including the noise) but is not going to predict future outcomes reliably (as the future experience will most likely not have the same noise). Conversely, if the model is missing important statistical effects (the extreme being a model that contains no explanatory variables and fits to the overall mean), the result is under-fitting. This model will predict future outcomes (e.g., in the extreme case mentioned above, the future mean) reliably but hardly help the modeler explain what is driving the result.

Appendix F includes additional examples and more details.

PRACTICAL CONSIDERATIONS

In practice, GLM routines are included in various commercial software packages, alleviating the burden of programming the underlying formulae and diagnostics. This does not imply, however, that the ratemaking actuary's role is at all diminished. In fact, the use of such methods means the actuary should focus attention on areas such as:

- ensuring data is adequate for the level of detail of the classification ratemaking analysis (avoiding what is known as the GIGO principle: Garbage In, Garbage Out)
- identifying when anomalous results dictate additional exploratory analysis
- reviewing model results in consideration of both statistical theory and business application
- developing appropriate methods to communicate model results in light of a company's ratemaking objectives (e.g., policyholder dislocation, competitive position)

This list is hardly exhaustive. The nature of statistical modeling for classification ratemaking is such that more work can always be done. The retrieval of data alone requires careful consideration of necessary volume of data; definition of homogeneous claim types; method of organization (e.g., policy year versus calendar-accident year); the treatment of midterm policy changes, large losses, underwriting changes during the experience period, and the effect of inflation and loss development. Actuaries always have to balance stability and responsiveness as it relates to choice of experience period as well as to geographies to be included in the analysis (e.g., countrywide versus individual state analysis). Most importantly, commercial considerations such as IT constraints, marketing objectives, and regulatory requirements have to be carefully incorporated into the statistical analysis before any results are implemented in practice.

The ratemaking actuary is best served to have a solid background in the company's data warehouses, to develop some understanding of statistical methods and diagnostics, and to work collaboratively with other professionals who have a solid understanding of the portfolio being analyzed. The ratemaking actuary should also communicate effectively with various stakeholders and ensure that technical results are ultimately expressed in relation to the company's business objectives.

DATA MINING TECHNIQUES

In addition to GLMs, many actuaries have become more familiar with various data mining techniques. The following is a brief, non-exhaustive survey of some methods used in practice. Though these techniques might not necessarily be used directly for producing rate differentials, they are often used to enhance the underlying classification analysis in various ways as described below.

Factor Analysis

Factor analysis, of which principle components analysis may be the most commonly used, is a technique to reduce the number of parameter estimates in a classification analysis (such as a GLM). This can imply a reduction in the number of variables or a reduction in the levels within a variable.

An example may best illustrate how factor analysis works. If one can summarize the exposure correlation between two variables in a scatter plot, a regression line can then be fit that summarizes the linear relationship between the two variables. A variable can then be defined that approximates this regression line. This combination variable essentially replaces the original variables and thereby reduces the parameter estimates of the model.

This technique might be used in ratemaking to compress a long list of highly correlated variables into a score variable (or a small number of uncorrelated score variables) that represents linear combinations of the original variables. For example, the vehicle symbols discussed earlier in this chapter may have been derived as a linear combination of correlated variables such as vehicle weight, vehicle height, number of cylinders, horsepower, cost when new, etc.. Another example is combining various geo-demographic variables, which are variables describing average characteristics of an area (e.g., population density, average proportion of home-ownership, average age of home, median number of rooms in the home, etc.)

Cluster Analysis

Cluster analysis is an exploratory data analysis tool that seeks to combine small groups of similar risks into larger homogeneous categories or “clusters.” It generally aims to minimize the differences within a category and maximize the difference between categories.

In practice, cluster analysis is most commonly used in rating for geography. Actuaries generally start with small geographic units (such as postal code or zip code) that are often quite granular. Cluster analysis applies a collection of different algorithms to group these units into clusters based on historical experience, modeled experience, or well-defined similarity rules. This allows easier incorporation into GLMs.

CART

The purpose of CART (Classification and Regression Trees) is to develop tree-building algorithms to determine a set of if-then logical conditions that help improve classification.

In personal automobile insurance, a resulting tree may start with an if-then condition around gender. If the risk is male, the tree then continues to another if-then condition around age. If the risk is male and youthful, the tree may then continue to an if-then condition involving prior accident experience. The tree “branch” for females may involve a different order or in fact, a completely different set of conditions.

Examination of the tree may help ratemaking actuaries identify the strongest list of initial variables (i.e., whittle down a long list of potential variables to a more manageable yet meaningful list) and determine how to categorize each variable. CART can also help detect interactions between variables.

MARS

The Multivariate Adaptive Regression Spline (MARS) algorithm operates as a multiple piecewise linear regression where each breakpoint defines a region for a particular linear regression equation. This technique is generally used to select breakpoints for categorizing continuous variables. For example, in homeowners insurance, amount of insurance may be treated as a categorical factor despite being continuous in nature. MARS can help select the breakpoints used to categorize the amount of insurance factor before using it in a GLM. MARS can also help detect interactions between variables.

Neural Networks

Neural networks are very sophisticated modeling techniques though they are often criticized for their lack of transparency. The neural network user gathers test data and invokes training algorithms designed to automatically learn the structure of the data. This technique has been described as a recursion applied to a GLM.

In practice, the results of a neural network can be fed into a GLM (or vice versa). This process helps highlight areas of improvement in the GLM (e.g., a missing interaction).

In general the data mining techniques listed above can enhance a ratemaking exercise by:

- whittling down a long list of potential explanatory variables to a more manageable list for use within a GLM;
- providing guidance in how to categorize discrete variables;
- reducing the dimension of multi-level discrete variables (i.e., condensing 100 levels, many of which have few or no claims, into 20 homogenous levels);
- identifying candidates for interaction variables within GLMs by detecting patterns of inter-dependency between variables.

A full survey of these and other methods is beyond the scope of this text. For more information, readers can reference "The Elements of Statistical Learning: Data Mining, Inference and Prediction" (Hastie et al. 2009).

AUGMENTING MULTIVARIATE ANALYSIS WITH EXTERNAL DATA

The adoption of GLMs also resulted in many companies seeking external data sources to augment what had already been collected and analyzed about their own policies. This includes but is not limited to information about:

- geo-demographics (e.g., population density of an area, average length of home ownership of an area);
- weather (e.g., average rainfall or number of days below freezing of a given area);
- property characteristics (e.g., square footage of a home or business, quality of the responding fire department);
- information about insured individuals or business (e.g., credit information, occupation).

This additional data can help actuaries further improve the granularity and accuracy of classification ratemaking. Almost certainly there will continue to be more and more reliable data available publically for actuaries to analyze and use in classification ratemaking.

SUMMARY

Much of the early history of classification ratemaking was based on rudimentary methods such as univariate analysis and later iteratively standardized univariate methods such as the minimum bias procedures. As computing power and data capabilities evolved, pioneering insurance companies employed multivariate methods in their classification ratemaking and moved the entire industry forward.

Grounded in statistical theory, multivariate methods adjust for an uneven mix of business and reflect the nature of the random process of insurance. They provide valuable diagnostics that aid in understanding the certainty and reasonableness of results. They can be refined to incorporate interaction variables. The litmus test of practicality is when multivariate methods are transparent and results can be incorporated in insurance company rating algorithms.

Generalized linear models have become the standard for classification ratemaking in most developed insurance markets—particularly because of the benefit of transparency. Understanding the mathematical underpinnings is an important responsibility of the ratemaking actuary who intends to use such a method. Linear models are a good place to start as GLMs are essentially a generalized form of such a model. As with many techniques, visualizing the GLM results is an intuitive way to connect the theory with the practical use.

GLMs do not stand alone as the only multivariate classification method. Other methods such as CART, factor analysis, and neural networks are often used to augment GLM analysis. Finally, the adoption of GLMs and data mining techniques influenced classification ratemaking in other ways as well—particularly in the incorporation of external data to enhance analysis.

KEY CONCEPTS IN CHAPTER 10

1. Shortcomings of univariate approach

2. Minimum bias techniques

3. Circumstances that led to the adoption of multivariate techniques
    a. Computing power
    b. Data warehouse initiatives
    c. Early adopters attaining competitive advantage

4. Overall benefits of multivariate methods
    a. Adjust for exposure correlations
    b. Allow for nature of random process
    c. Provide diagnostics
    d. Allow interaction variables
    e. Considered transparent

5. Mathematical foundation of generalized linear models (GLMs)

6. Sample GLM output

7. Statistical diagnostics, practical tests, and validation techniques
    a. Standard errors
    b. Deviance tests
    c. Consistency with time
    d. Comparison of model results and historical results on hold-out sample

8. Practical considerations

9. Data mining techniques
    a. Factor analysis
    b. Cluster analysis
    c. CART
    d. MARS
    e. Neural networks

10. Incorporation of external data in multivariate classification analysis

CHAPTER 11: SPECIAL CLASSIFICATION

As discussed in Chapters 9 and 10, companies that can determine and implement equitable rates are able to insure a broader range of risk profitably and, therefore, have a competitive advantage. Companies that choose not to do so may face adverse selection.

The past two chapters discussed traditional (univariate) and multivariate techniques that determine the indicated relativities between different levels of a given rating variable. Certain rating variables and risk characteristics have unique qualities that led actuaries to develop special ratemaking procedures.

This chapter discusses alternate ratemaking procedures to address the following items:

- Territorial boundary analysis
- Increased limits factors
- Deductibles
- Workers compensation size of risk
- Insurance to value/Coinsurance

TERRITORIAL RATEMAKING

Geography is considered one of the primary drivers of claims experience. Consequently, it is one of the most well-established and widely used rating variables. Companies typically define territories as a collection of small geographic units (e.g., postal/zip codes, counties, census blocks) and have rate relativities for each territory. The territorial boundaries and associated rate relativities can vary significantly from insurer to insurer.

Territorial ratemaking poses some interesting challenges. First, location tends to be heavily correlated with other rating variables (e.g., high-value homes tend to be located in the same area), which makes traditional univariate analysis of location very susceptible to distortions. Second, as companies often analyze territory as a collection of small units, the data in each individual territory is sparse. This is referred to as high-dimensionality, and special multivariate techniques are required to circumvent the problem.

Territorial ratemaking generally involves two phases:

- Establishing territorial boundaries
- Determining rate relativities for the territories

Establishing Territorial Boundaries

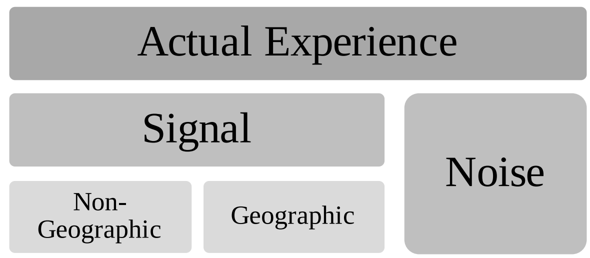
In the past, companies had few rating territories and, for many lines, most companies used the same or very similar territorial boundaries. Often these territories were developed by a third-party (e.g., ISO or NCCI) using industry data. Over time, companies began to subdivide (or modify) the territories to try to gain a competitive advantage. In many cases, the refinement was based on operational knowledge of the area and judgment. Recently, actuaries are applying more advanced methods such as geo-spatial techniques to develop or refine territorial boundaries. Actuaries are also using both internal and external data in their analyses.

Determining Geographic Unit

The first step in establishing territorial boundaries is to determine the basic geographic unit. The unit should be refined enough to be relatively homogenous with respect to geographic differences while still having some observations in most units. Typical units are postal codes (zip codes in the U.S.), census blocks, counties, or some combination of these. Each of these options has practical advantages and disadvantages. For example, while zip codes have the advantage of being the most readily available, they have the disadvantage of changing over time. Counties have the advantage of being static and readily available; however, due to the large size of most counties, they tend to contain very heterogeneous risks. Census blocks are relatively static over time, but require a process to map insurance policies to the census blocks.

Once the basic geographic unit is determined, the actuary's objective is to estimate the geographic risk associated with each unit. Actual experience reflects both signal and random noise. The signal is driven by non-geographic elements (e.g., age, amount of insurance, number of employees) and geographic elements (e.g., density, weather indices, crime rates). The different components are shown in Figure 11.1; the key to accurately estimating the geographic risk is isolating the geographic signal in the data.

11.1 Components of Actual Experience



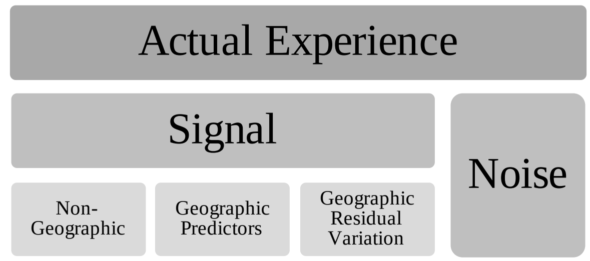
Calculating the Geographic Estimator

Traditionally, the actuary used univariate techniques (e.g., pure premium approach) to develop an estimator for each geographic unit. There are two major issues with this approach. First, the geographic estimator in this approach reflects both the signal and the noise. Since geographic units tend to be small, the data is often sparse and either the resulting loss ratios or pure premiums or both will typically be too volatile to distinguish the noise from the signal. Second, since location tends to be highly correlated with other non-geographic factors, the resulting estimator is biased.[37]

A more sophisticated approach involves building a multivariate model (e.g., a GLM) on loss cost data using a variety of non-geographic and geographic explanatory variables. The non-geographic variables include many traditional rating variables (e.g., age of insured, claim history) as well as other explanatory variables that may not currently be used in rating. The geographic variables can include geo-demographic variables (e.g., population density) and geo-physical variables (e.g., average rainfall). The geo-demographic and geo-physical variables are often obtained from third-party sources and merged with the insurance company database via some geographic unit, although it does not have to be the same as the selected basic geographic unit.

[37] The same comments made in Chapter 9 regarding this bias apply. In other words, actuaries using the loss ratio approach generally assume the rates are equitable and make no adjustments. Actuaries using the pure premium approach may adjust the exposures to account for distributional bias.

11.2 Components of Actual Experience Further Refined



The very nature of the multivariate modeling process enables the actuary to isolate the signal from the noise in the data. Since the variables and interactions included in the model are only a subset of the universe of predictive variables, there may be unexplained signal in the model residuals. Given that geography is a useful basis for examining patterns in the residuals, actuaries often examine the geographic residual variation. The parameters from each of the various geographic predictors, including a predictor variable for the geographic residual variation, can be combined to form one composite risk index or score that represents the geographic signal for each geographic unit.

Smoothing

Geographic risk tends to be similar for units that are close in proximity. Consequently, actuaries may use spatial smoothing techniques to improve the estimate of any individual unit by using information from nearby units. There are two basic types of spatial smoothing: **distance-based** and **adjacency-based**.

The **distance-based** approach smoothes by weighting the information from one geographic unit with the information from all nearby geographic units based on the distance from the primary unit and some measure of credibility. The influence of nearby areas is deemed to diminish with increasing distance.

Distance-based smoothing has the advantage of being easy to understand and implement. A disadvantage to this approach is the assumption that a certain distance (e.g., a mile) has the same impact on similarity of risk regardless of whether it is an urban or rural area. Additionally, the presence of a natural or artificial boundary (e.g., river or highway) between two geographic units is not taken into consideration when determining distance. This assumption tends to be most appropriate for weather-related perils.

Adjacency-based smoothing weights the information from one geographic unit with the information estimators of rings of adjacent units (i.e., immediately adjacent units get more weight than the units adjacent to adjacent units, etc). Adjacency-based smoothing handles urban/rural differences more appropriately, and accounts for natural or artificial boundaries better than the distance-based smoothing. For these reasons, adjacency-based smoothing tends to be most appropriate for perils driven heavily by socio-demographic characteristics (e.g., theft).

Whether distance or adjacency-based smoothing is used, the actuary needs to balance over- and under-smoothing. If the actuary smoothes too much (e.g., uses data from dissimilar units in another part of the state), the actuary may be masking the real spatial variation among the risks. If the actuary does not smooth enough, the actuary may be leaving considerable noise in the estimator.

The exact mechanics of the various spatial smoothing techniques are beyond the scope of this text.

Smoothing techniques are generally applied in one of two ways. First, smoothing techniques can be applied to the geographic estimators themselves. This is most commonly done when the geographic estimator is based on the univariate approaches as the estimators generally still contain a significant amount of noise. Second, these techniques can be applied within a more sophisticated framework to improve the predictive power of a multivariate analysis of geographical effects. In this case, the actuary applies smoothing techniques to the geographic residuals to see if there are any patterns in the residuals;

in other words, the actuary tries to detect any systematic geographic patterns that are not explained by the geographical factors in the multivariate model. Any pattern in the residuals (i.e., the residuals are all positive or negative in a certain region) indicates the existence of geographic residual variation. Once identified, the spatially smoothed residuals can be used to adjust the geographic estimators to improve the overall predictive power of the model.

Clustering

Once the geographic estimators are calculated for each unit, the units can be grouped into territories. When combining units, the goal is to minimize within group heterogeneity and maximize between group heterogeneity. As with smoothing techniques, there are a variety of clustering techniques that can achieve this. The following are basic categories of clustering routines:

- Quantile methods create clusters based on either equal numbers of observations (such as geographic units) or equal weights (such as exposure).
- Similarity methods create clusters based on how close the estimators are to one another. The definition of closeness can be based on a few different statistics:
    - The average linkage similarity method creates boundaries based on the overall average difference between the estimators from one cluster to the next. This tends to join clusters with smaller variances.
    - The centroid similarity method creates boundaries based on the overall average difference in estimators squared. This tends to be more responsive to outliers.
    - Ward's clustering method creates boundaries that lead to the smallest within cluster sum of squares difference. This tends to produce clusters that have the same number of observations.

It is important to note that these types of clustering routines do not naturally produce contiguous groupings (i.e., groupings that only include geographic units that are adjacent to each other). If the actuary desires contiguous territorial boundaries, then a contiguity constraint needs to be added to the clustering routine.

In the absence of some natural or man-made "boundary," the level of geographic risk generally changes gradually. By creating distinct boundaries, there will be a discontinuity at the boundary. If there are too few clusters, there may be a significant jump in estimated risk between two adjacent clusters, which is undesirable. Thus, the actuary should select the number of clusters that minimizes noise without creating significant discontinuities. Interestingly, many companies have eliminated the grouping of units into territories and simply derive rate relativities for each geographic unit; practically speaking, that is no different than creating a significant number of small territories. If done properly, this minimizes extreme discontinuities between units. Ultimately, rather than having rating territories, many companies will geo-code every risk, and the latitude and longitude of the insured item will create a unique rate relativity that changes gradually from one location to a neighboring location.

Calculating Territorial Relativities

Once the boundary definitions have been determined, the actuary determines the associated rate relativities or differentials. This can be accomplished using the techniques described in the prior two chapters. Since location tends to be highly correlated with other variables (e.g., low- or high-valued homes tend to be concentrated in certain areas), it is prudent to perform this analysis using multivariate classification techniques. For example, the new territorial boundaries could be modeled along with various other explanatory variables in a GLM.

INCREASED LIMITS RATEMAKING

Insurance products that provide protection against third-party liability claims usually offer the insured different amounts of insurance coverage, referred to as limits of insurance. Typically, the lowest level of insurance offered is referred to as the basic limit, and higher limits are referred to as increased limits.

Establishing appropriate rate differentials for each limit (referred to as increased limits ratemaking) is growing in importance for several reasons. First, as personal wealth continues to grow, individuals have more assets to protect and need more insurance coverage. Second, general inflation drives up costs and, as discussed in Chapter 6, trends in costs have a greater impact on increased limits losses than on basic limits losses. Third, the propensity for lawsuits and the amount of jury awards have increased significantly (i.e., social inflation). Like general inflation, this has a disproportionate impact on the increased limits losses.

Particular lines of insurance where increased limits are of extreme importance include private passenger and commercial auto liability, umbrella, and any commercial product offering liability coverage such as contractor's liability, professional liability, etc. There are two types of policy limits offered: single limits and compound limits. A single limit refers to the total amount the insurer will pay for a single claim. For example, if an umbrella policy has a limit of $1,000,000, then the policy will only pay up to $1,000,000 for any one claim.

A compound limit applies two or more limits to the covered losses. A compound limit that includes both a per claimant and a per occurrence limit is commonly referred to as a split limit. For example, in personal automobile insurance, a split limit for bodily injury liability of $15,000/$30,000 means that in the event the insured causes an accident, the policy will pay each injured party up to $15,000 with the total payment to all injured parties not to exceed $30,000. Another common compound limit is an occurrence/aggregate limit; it limits the amount payable for any one occurrence and for all occurrences incurred during the policy period. For example, assume an annual professional liability policy has a limit of $1,000,000/$3,000,000. The policy will not pay more than $1,000,000 for any single occurrence and will not pay more than $3,000,000 for all occurrences incurred during the policy period.

The focus of this section will be on determining indicated increased limit factors (ILFs) for a single limit. Compound and split limits are more complex in that both limits must be considered.

Standard ILF Approach

It is possible to aggregate policies based on the limit purchased and to use univariate (e.g., loss ratio or pure premium) analysis or multivariate techniques (e.g., GLMs) to calculate indicated rate differentials for the various limits (commonly referred to as "increased limits factors"). However, since increased limits offer protection for larger, less common liability claims, the data per limit tends to be very sparse and the results can be very volatile. Consequently, actuaries often use special techniques for increased limits ratemaking.

Similar to other rating variables, the increased limit factor (ILF) is used to modify the base rate (*B*, which assumes the basic limit) if the insured selects a limit of liability (*H*) that is different than the basic limit.

$$\text{Rate at Limit } H = \text{ILF for Limit } H \times B.$$

Making the assumption that all underwriting expenses are variable and that the variable expense and profit provisions do not vary by limit, the formula for the indicated ILF is derived in the same way as Chapter 9:

$$\text{Indicated ILF}(H) = \frac{(\overline{L + E_{\text{L}}})_H}{(\overline{L + E_{\text{L}}})_B}.$$

Actuaries may elect to vary the profit provision by limit, which violates the assumption in the previous paragraph. Because higher limits offer additional coverage for claims that are less frequent and very severe, the experience for these limits can be volatile. The greater variability adds uncertainty that makes these limits challenging to price and risky for insurers; consequently, insurers may alter the profit provision in the rates to reflect the higher cost of capital needed to support the additional risk. The actuary also typically makes the simplifying assumption that frequency and severity are independent so that:

$$\text{Indicated ILF}(H) = \frac{\text{Frequency}_H \times \text{Severity}_H}{\text{Frequency}_B \times \text{Severity}_B}.$$

Making the final assumption that the frequency is the same regardless of the limit chosen, the formula simplifies to:

$$\text{Indicated ILF}(H) = \frac{\text{Severity}_H}{\text{Severity}_B}.$$

For some lines of business, data suggests that the frequency of losses may vary by the limit chosen. For example, personal automobile insureds who select a very high limit tend to have lower accident frequencies than insureds who select low limits. One common explanation for this is that the selection of a higher limit tends to be a sign of risk aversion and a higher degree of overall responsibility that applies to driving behavior, too.

If the actuary is willing to accept all of these simplifying assumptions, the indicated ILF for a given limit *H* is equal to the severity of losses limited at *H* divided by the severity of losses limited at *B*. A severity limited at *H* is often referred to as the limited average severity at *H* or LAS (*H*). Using this notation:

$$\text{Indicated ILF}(H) = \frac{\text{LAS}(H)}{\text{LAS}(B)}.$$

LAS (*H*) is the severity assuming every loss is capped at limit *H* (regardless of the actual policy limit), and LAS (*B*) is the severity assuming every loss is capped at the basic limit. If the actuary knows the full amount of each loss assuming no policy limits, then this calculation is straightforward.

To illustrate this, assume the following 5,000 reported uncensored claims categorized by the size of the loss (i.e., a $150,000 loss is slotted in the $100,000<*X*<=$250,000 range):

11.3 Size of Loss Distribution

Size of Loss			Reported Claims	Reported Losses
	X <=	$ 100,000	2,324	$ 117,629,223
$ 100,000	< X <=	$ 250,000	1,923	$ 307,599,929
$ 250,000	< X <=	$ 500,000	680	$ 222,793,514
$ 500,000	< X <=	$ 1,000,000	73	$ 43,047,470
	Total		5,000	$ 691,070,136

The average severity limited to $100,000, or LAS ($100,000), is calculated by capping every claim at $100,000 and dividing by the total number of claims. All 2,324 claims in the first interval have individual sizes of loss less than $100,000, so these losses are uncapped. The other 2,676 claims in the other three intervals have individual sizes of loss that exceed $100,000 and are, therefore, capped at $100,000; the resulting capped losses for these claims are $267,600,000 (= 2,676 x $100,000). The sum of those amounts ($385,229,223 = $117,629,223 + $267,600,000) is divided by the total claim count.

Using this technique, the increased limit factor for $250,000 is calculated as follows:

$$\text{LAS}(\$100\text{K}) = \frac{\$117{,}629{,}223 + (1{,}923 + 680 + 73) \times \$100{,}000}{5{,}000} = \$77{,}046,$$

$$\text{LAS}(\$250\text{K}) = \frac{\$117{,}629{,}223 + \$307{,}599{,}929 + (680 + 73) \times \$250{,}000}{5{,}000} = \$122{,}696,$$

$$\text{Indicated ILF}(\$250\text{K}) = \frac{\text{LAS}(\$250\text{K})}{\text{LAS}(\$100\text{K})} = \frac{\$122{,}696}{\$77{,}046} = 1.59.$$

Censored Losses

The losses used in the example above are uncensored losses. In other words, the loss data reflected the full amount of the loss assuming no policy limits. Unfortunately, the data available to the actuary is typically censored at the policy limit; consequently, the actuary does not know the full amount of the loss. For example, assume an insured with a $50,000 policy limit has an at-fault accident in which the injured third party has $150,000 worth of medical costs. The claims database will likely only reflect the amount paid by the insurer (i.e., $50,000) rather than the amount the claim would be in the absence of any limit ($150,000).

To further illustrate this point, consider the case that 2,019 of the 5,000 claims in the example above came from policies with a $100,000 limit. The uncensored losses for these policies are as follows:

11.4 Uncensored Loss Distribution of Policies with $100,000 Limit

Size of Loss			Reported Claims	Reported Losses
	X <=	$ 100,000	922	$ 46,957,898
$ 100,000	< *X* <=	$ 250,000	787	$ 127,573,028
$ 250,000	< *X* <=	$ 500,000	282	$ 92,665,855
$ 500,000	< *X* <=	$ 1,000,000	28	$ 16,640,606
	Total		2,019	$ 283,837,387

Assuming the insurer's data contains only the censored losses, the loss distribution available to the actuary is represented in the right-hand portion of the table below:

11.5 Censored Loss Distribution of Policies with $100,000 Limit

Size of Loss			Uncensored Claims	Uncensored Losses	Censored Claims	Censored Losses
	X <=	$ 100,000	922	$ 46,957,898	2,019	$ 156,657,898
$ 100,000	< *X* <=	$ 250,000	787	$ 127,573,028		
$ 250,000	< *X* <=	$ 500,000	282	$ 92,665,855		
$ 500,000	< *X* <=	$ 1,000,000	28	$ 16,640,606		
	Total		2,019	$ 283,837,387	2,019	$ 156,657,898

Assuming the insurer writes three policy limits ($100,000, $250,000, and $500,000) and the historical database contains only censored losses, the 5,000 losses censored at the applicable policy limit appear in the data as follows:

11.6 Censored Loss Distribution by Policy Limit

Size of Loss			$100,000 Limit Claims	$100,000 Limit Losses	$250,000 Limit Claims	$250,000 Limit Losses	$500,000 Limit Claims	$500,000 Limit Losses
	X <=	$ 100,000	2,019	$ 156,657,898	690	$ 34,903,214	712	$ 35,768,111
$ 100,000	< *X* <=	$ 250,000			773	$ 142,767,479	574	$ 90,009,422
$ 250,000	< *X* <=	$ 500,000					232	$ 81,092,725
$ 500,000	< *X* <=	$ 1,000,000						
	Total		2,019	$ 156,657,898	1,463	$ 177,670,693	1,518	$ 206,870,258

When calculating the limited average severity for each limit, the actuary should use as much data as possible without allowing any bias due to censorship. The general approach is to calculate a limited average severity for each layer of loss and combine the estimates for each layer taking into consideration the probability of a claim occurring in the layer. The limited average severity of each layer is based solely on loss data from policies with limits as high as or higher than the upper limit of the layer.

For example, when calculating the LAS ($100K), the actuary can use the experience from all policies (even those with limits above $100,000) and censor at $100,000:

$$\text{LAS(\$100K)} = \frac{\$156{,}657{,}898 + \$34{,}903{,}214 + \$35{,}768{,}111 + \$100{,}000 \times (773 + 574 + 232)}{5{,}000},$$

$$\text{LAS(\$100K)} = \frac{\$385{,}229{,}223}{5{,}000} = \$77{,}046.$$

When calculating the LAS ($250,000), the actuary cannot use the policies that have a $100,000 limit as there is no way to know what the claim amounts would be if each of those policies had a limit of

$250,000. Instead, the actuary can combine the LAS ($100K) with a limited average severity for the layer between $100,000 and $250,000. To do this, the actuary first needs to determine the losses in that second layer.

By definition, policies with a limit of $100,000 do not contribute any losses to that layer and the data is not used.

Of the 1,463 claims associated with policies having a limit of $250,000, there are 773 claims with sizes of loss in that layer. The total censored losses for those 773 claims are $142,767,479. Eliminating the first $100,000 of each of those losses results in $65,467,479 of losses in the layer between $100,000 and $250,000:

$$\$65{,}467{,}479 = \$142{,}767{,}479 - 773 \times \$100{,}000.$$

Policies with a limit of $500,000 also contribute loss dollars to the layer between $100,000 and $250,000. Of the 1,518 claims associated with a limit of $500,000, there are 574 claims that have losses in the $100,000 to $250,000 layer. These claims contribute $32,609,422 of losses to the layer:

$$\$32{,}609{,}422 = \$90{,}009{,}422 - 574 \times \$100{,}000.$$

Another 232 claims exceed $250,000, and each contributes $150,000 to the layer for a total of $34,800,000:

$$\$34{,}800{,}000 = 232 \times (\$250{,}000 - \$100{,}000).$$

Combining all of those figures yields the following loss dollars in the layer $100,000 to $250,000:

$$\$132{,}876{,}901 = \$65{,}467{,}479 + \$32{,}609{,}422 + \$34{,}800{,}000.$$

Given that those loss dollars were derived from 1,579 (=773+574+232) claims, the limited average severity for the layer between $100,000 and $250,000 is:

$$\$84{,}153 = \frac{\$132{,}876{,}901}{1{,}579}.$$

Before combining this with the LAS ($100K), the actuary needs to adjust for the fact that these losses are based on a subset of the claims used to calculate the LAS ($100K). The adjustment involves calculating the probability that the loss will exceed $100,000, given that a claim occurs. Since the actuary cannot know whether or not the claims from the policies with a $100,000 limit would have exceeded $100,000, that data is not used for this calculation. To adjust this, the limited average severity for the layer between $100,000 and $250,000 can be multiplied by the following probability:

$$\Pr(X >= \$100K) = \frac{773 + 574 + 232}{1{,}463 + 1{,}518} = \frac{1{,}579}{2{,}981}.$$

This is equivalent to dividing the losses in the layer by the total claim count for those policies:

$$\$44{,}575 = \$84{,}153 \ x \ \frac{1{,}579}{2{,}981} = \frac{\$132{,}876{,}901}{2{,}981}.$$

Given these calculations,

$$\text{LAS}(\$250\text{K}) = \$77{,}046 + \$44{,}575 = \$121{,}621.$$

These same techniques can be applied to calculate LAS ($500K). Only the policies with a limit of $500,000 or greater can be used to determine the contribution from the layer between $250,000 and $500,000:

$$\$15{,}213 = \frac{\$81{,}092{,}725 - 232 \times \$250{,}000}{1{,}518}.$$

Given this,

$$\text{LAS}(\$500\text{K}) = \$77{,}046 + \$44{,}575 + \$15{,}213 = \$136{,}834.$$

Other Considerations

The increased limits ratemaking analyses outlined above are intended to produce rate relativities for future policies; therefore, historical losses used in the analysis should be adjusted for any expected trend. This is especially relevant with increased limits losses. Recall from Chapter 6 that loss trends have a leveraged effect on increased limits losses. More specifically, assuming a constant positive percentage trend in total losses, the following relationship holds:

$$\text{Basic Limits Trend} \leq \text{Total Limits Trend} \leq \text{Increased Limits Trend}.$$

See Table 6.15 in Chapter 6 for a numeric example that demonstrates this relationship.

Also, depending on how recent the empirical data is, the claims may not be settled. Since larger claims often develop differently than smaller claims, this can have an impact on the calculation of the increased limit factors. Ideally, all claims should be developed to ultimate before the application of these techniques.

In addition to censoring through policy limits, losses may also be truncated from below if there is a deductible applied to the policy. While it is possible to "add back" the amount of dollars eliminated due to the deductible on known claims, it may not be possible to know how many claims were completely eliminated due to the deductible.

Fitted Data Approach

The prior approach used historical loss data to calculate the indicated increased limit factors. That approach depends heavily on the existence and nature of the claims in the layers of loss being studied. Given the relatively rare nature of large claims, the results using that approach may be volatile.

Consequently, actuaries may fit curves to empirical data to smooth out the random fluctuations in the data. Common distributions include lognormal, Pareto, and the truncated Pareto.

Assuming $f(x)$ represents a continuous distribution of losses of size x, and H is the limit being priced, then the formula for the limited average severity is given by:

$$\text{LAS}(H) = \int_0^H xf(x)dx + H\int_H^\infty f(x)dx.$$

The severity is based on claims that are less than the limit and claims that are censored by the limit. The first term is the loss amount for all claims less than the limit multiplied by the probability of those claims occurring. The second term represents the limit multiplied by the probability that the loss exceeds the limit. The sum of the two terms equals the limited average severity.

Thus, the increased limit factor for the limit H is represented as follows:

$$\text{ILF}(H) = \frac{\int_0^H xf(x)dx + H\int_H^\infty f(x)dx}{\int_0^B xf(x)dx + B\int_B^\infty f(x)dx}.$$

The major challenge with this approach is determining a distribution that is representative of the expected losses.

ISO Mixed Exponential Methodology

The ISO Mixed Exponential Methodology is an advanced approach designed to address some of the issues with the empirical data (trend, censoring by policy limits, etc.). This is an advanced topic and is outside the scope of this text. For more information on this approach, refer to “Increased Limits Ratemaking for Liability Insurance” (Palmer 2006, pp. 19-25).

Multivariate Approach

As discussed in Chapter 10, many actuaries analyze increased limits factors within a multivariate framework. Techniques such as generalized linear models can cope more effectively with sparse data, but this is still an issue for the very high, thinly populated limits. A major difference between a GLM approach and the univariate approaches using limited average severities is that the GLM does not assume the frequency is the same for all risks. Therefore, the GLM results are influenced by both the limiting of losses and the behavioral differences among insureds at different limits. This may produce counter-intuitive results (e.g., expected losses decrease as limit increases). Consequently, actuaries may use both approaches to guide the selection of increased limit factors.

DEDUCTIBLE PRICING

Many early insurance policies were written on a full coverage basis (i.e., the policy covered the entire loss amount). Over time, insurance companies introduced deductible clauses in which the insured is responsible for the first dollars of loss up to the deductible amount, and the insurer pays the amount greater than the deductible, up to applicable policy limits.

There are two basic types of deductibles: flat dollar deductibles and percentage deductibles.[38] Flat dollar deductibles are the most prevalent. As the name suggest, a flat dollar deductible (e.g., $250 deductible) specifies a dollar amount below which losses are not covered by the policy. Flat dollar deductibles may range from very small amounts (e.g., $100 or $250) on personal lines policies to very large deductibles (e.g., $100,000 or more) on large commercial policies. Percentage deductibles state the deductible as a percentage of the coverage amount. For example, a 5% deductible on a home insured for $500,000 is equivalent to a flat dollar deductible of $25,000. These types of deductibles are most prevalent on property policies, and are often applied specifically to perils that are susceptible to catastrophic losses (e.g. earthquake or hurricane).

There are several reasons why deductibles are popular among both insureds and insurers, some of which are listed below:

- **Premium reduction:** The application of a deductible reduces the rate as the insured is responsible for a portion of the losses. Often the insured (whether an individual or company) may be willing to cover the amount under the deductible in exchange for a lower premium.
- **Eliminates small nuisance claims:** Under a full coverage policy, insureds have an incentive to file every claim. Insurance companies incur loss adjustment expenses in the process of settling reported claims. The expense associated with investigating and handling small claims frequently costs more than the actual claim amount. Deductibles minimize the occurrence of these small nuisance claims. By doing this, insurers can better control LAE and keep the rates lower than would otherwise be possible.
- **Provides incentive for loss control:** Since the insured is responsible for the first layer of loss, the insured has a financial incentive to avoid losses.
- **Controls catastrophic exposure:** When an insurer writes a significant number of policies in a given area, the insurer may be susceptible to very large aggregate losses in the case of a catastrophic event. By including large catastrophe deductibles, the insurer can significantly reduce overall exposure to such losses and reduce the overall risk of insolvency.

Loss Elimination Ratio (LER) Approach

It is possible to group data by deductible and use the techniques described in Chapters 9 and 10 to determine rate relativities for each deductible amount. Alternatively, actuaries have determined deductible relativities using a loss elimination ratio (LER) approach.

[38] A third type of deductible, used in a small number of insurance products (e.g., crop hail insurance) is the disappearing deductible. With a disappearing deductible, the insured is still responsible for the first dollars of loss. However, this amount decreases, or disappears, as the size of the claim increases until at a certain point the insured's retained losses are zero. Since this type of deductible is not commonly used in practice today, this text will not further address disappearing deductibles.

Using the assumptions that all expenses are variable and that the variable expenses and profit are a constant percentage of premium, the indicated deductible relativity for deductible *D* is given by the following formula (where the base level in this example assumes no deductible):

$$\text{Indicated Deductible Relativity} = \frac{(\overline{L+E_{\mathrm{L}}})_D}{(\overline{L+E_{\mathrm{L}}})_B}.$$

In other words, the indicated deductible relativity is equivalent to the ultimate losses and LAE after application of the deductible divided by the ground-up ultimate losses and LAE (i.e., no deductible). In the LER approach, the actuary calculates the amount of losses that are eliminated going from full coverage to a deductible, or by going from one deductible to a higher deductible:

$$\mathrm{LER}(D) = \frac{\text{Losses and LAE Eliminated by Deductible}}{\text{Total Ground-up Losses and LAE}} = \frac{(L+E_{\mathrm{L}})_B - (L+E_{\mathrm{L}})_D}{(L+E_{\mathrm{L}})_B}.$$

That formula can be re-written as follows:

$$(L+E_{\mathrm{L}})_D = (L+E_{\mathrm{L}})_B \times (1.0 - \mathrm{LER}(D)).$$

The indicated deductible relativity can be restated as:

$$\text{Indicated Deductible Relativity} = \frac{(\overline{L+E_{\mathrm{L}}})_B \times (1.0 - \mathrm{LER}(D))}{(\overline{L+E_{\mathrm{L}}})_B} = (1.0 - \mathrm{LER}(D)).$$

Empirical Distribution (Discrete Case)

If the ground-up loss is known for every claim, the LER can be calculated as follows:

$$\mathrm{LER}(D) = (1 - \frac{\sum_{\text{All Losses}} \text{Maximum}\left[0, (\text{Loss Amount} - D)\right]}{\sum_{\text{All Losses}} \text{Loss Amount}}).$$

To demonstrate the discrete approach for determining loss elimination ratios, consider the following table of ground-up homeowners losses:

11.7 Size of Loss Distribution

(1) Size of Loss	(2) Reported Claims	(3) Ground-Up Reported Losses
$ - <= X < $ 100	3,200	$240,365
$ 100 <= X < $ 250	1,225	$207,588
$ 250 <= X < $ 500	1,187	$463,954
$ 500 <= X < $1,000	1,845	$1,551,938
$ 1,000 <= X <	2,543	$11,140,545
TOTAL	10,000	$13,604,390

To calculate the loss elimination ratio for a $250 deductible denoted as LER ($250), the actuary determines the amount of losses in each layer that will be eliminated by the deductible. The first two rows of data only contain losses that are less than $250, which will be completely eliminated by the deductible. The remaining rows contain individual losses that are at least $250; therefore, $250 will be eliminated for each of the 5,575 claims (or $1,393,750 in total). The LER is calculated as losses eliminated divided by the total losses:

$$\text{LER}(\$250) = \frac{(\$240{,}365 + \$207{,}588) + \$250 \times (1{,}187 + 1{,}845 + 2{,}543)}{\$13{,}604{,}390} = 0.135.$$

Thus without any further adjustments, the rate credit for going from full coverage to a $250 deductible is 13.5%; alternatively, this can be restated as a deductible relativity by subtracting 0.135 from 1.0 (i.e., 0.865).

The following table shows the calculations discussed above:

11.8 LER Calculation for $250 Deductible

(1) Size of Loss	(2) Reported Claims	(3) Ground-Up Reported Losses	(4) Losses Eliminated by $250 deductible
$ - <=X< $ 100	3,200	$240,365	$240,365
$ 100 <=X< $ 250	1,225	$207,588	$207,588
$ 250 <=X< $ 500	1,187	$463,954	$296,750
$ 500 <=X< $1,000	1,845	$1,551,938	$461,250
$ 1,000 <=X<	2,543	$11,140,545	$635,750
TOTAL	10,000	$13,604,390	$1,841,703
	(5) LER		0.135

$(4)_{\text{Losses}<250}$ = (3)
$(4)_{\text{Losses}>=250}$ = (2) x $250
(5) = (Tot4) / (Tot3)

Other Considerations

The aforementioned calculations were possible because the ground-up losses were known. The company may not know the ground-up losses for every claim. For example, insureds may not report claims that are obviously less than the deductible on their policy. In this case, the database may only include censored losses (i.e., the portion of reported losses that exceed the deductible); these losses are commonly referred to as net losses. When this is the case, data from policies with deductibles greater than the deductible being priced cannot be used to calculate the loss elimination ratio. For example, data from policies with a $500 deductible cannot be used to determine loss elimination ratios for a $250 or $100 deductible. However, data from policies with deductibles less than the deductible being priced can be used to determine loss elimination ratios (e.g., data from policies with a $500 deductible can be used to determine the loss elimination ratio associated with moving from a $750 deductible to a $1,000 deductible). It is common for the actuary to aggregate the data from all policies with a lower deductible to increase the volume of data used in the loss elimination ratio analysis.

The following example shows the calculation of the credit to change from a $250 to a $500 deductible. Each row contains data for policies with different deductible amounts. Since the goal is to determine the losses eliminated when changing from a $250 to a $500 deductible, the analysis can only use policies with deductibles of $250 or less. Columns 4 and 5 contain the net reported losses in Column 3 restated to $500 and $250 deductible levels, respectively.[39] The losses eliminated by moving from a $250 to a $500 deductible are the difference between the two columns. The LER equals the eliminated losses divided by the total losses at the $250 level.

11.9 LER Calculation to Move from a $250 to $500 Deductible

(1) Deductible	(2) Reported Claims	(3) Net Reported Losses	(4) Net Reported Losses Assuming $500 Ded	(5) Net Reported Losses Assuming $250 Ded	(6) Losses Eliminated
Full Cov	500	$680,220	$524,924	$588,134	$63,210
$100	680	$1,268,403	$1,049,848	$1,176,269	$126,421
$250	1,394	$2,940,672	$2,624,621	$2,940,672	$316,051
$500	2,194	$5,249,242	$5,249,242	Unknown	Unknown
$1,000	254	$859,755	Unknown	Unknown	Unknown
TOTAL	5,022	$10,998,292			
		(7) Net Reported Losses for Ded <=$250			$4,705,075
		(8) Losses Eliminated <=$250 Ded			$505,682
		(9) LER			0.107

(3)=	Net of the deductible
(4)=	(3) Adjusted to a $500 deductible
(5)=	(3) Adjusted to a $250 deductible
(6)=	(5) - (4)
(7)=	Sum of (5) for $0, $100, $250 Deductibles
(8)=	Sum of (6) for $0, $100, $250 Deductibles
(9)=	(8) / (7)

The same comments made earlier with respect to trend and development in the Increased Limit Factors section apply to deductible pricing, too.

Fitted Data Approach

The LER can be calculated given a continuous distribution of losses. Assume $f(x)$ represents a continuous distribution of losses of size x, and D is the size of the deductible. The eliminated losses equal the sum of all losses less than the deductible D and the deductible amount for every loss that exceeds D.

[39] Columns 4 and 5 are not simply Column 3 minus the product of Column 2 and the assumed deductible. This is because not every reported loss exceeds the assumed deductible. The losses in Columns 4 and 5 are based on an assumed distribution of losses by deductible and size of loss, and cannot be recreated given the data shown.

This formula is very similar to the formula used in the increased limit factor section and calculates the expected loss eliminated through the application of a deductible, *D*.

$$\int_0^D xf(x)dx + D\int_D^\infty f(x)dx.$$

The LER is calculated by dividing this formula by the unlimited expected loss:

$$\text{LER}(D) = \frac{\int_0^D xf(x)dx + D\int_D^\infty f(x)dx}{\int_0^\infty xf(x)dx}.$$

Practical Considerations

Like the ILF pricing, the LER approach assumes claiming behavior will be the same for each deductible. This may not be the case. The LER approach assumes an insured with a $250 deductible and an insured with a $1,000 deductible will both report a $1,100 loss. In reality, the same insured who reports the claim under a $250 deductible policy may choose not to report the claim under a $1,000 deductible policy for fear of an increase in premium from the insurer applying a claim surcharge (i.e., the small net payment of $100 is not worth the increase in premium). This difference in behavior is ignored in loss elimination ratio calculations.

Furthermore, when insureds are allowed to freely choose their policy deductible, lower-risk insureds tend to choose higher deductibles. Presumably, those insureds realize they are unlikely to have a claim and are willing to accept the risk associated with a higher deductible. Since the LER approach does not recognize these behavioral differences, higher deductible policies may end up being more profitable than lower deductible policies.

If insureds are not allowed to self-select and are forced to purchase higher deductibles, this phenomena will not be present. In fact, it is possible that the insureds who wanted a lower deductible may try to artificially inflate claims to make up the additional deductible amount.

An analysis using the techniques described in Chapters 9 and 10 will reflect behavioral differences among deductible options inherent in the historical data. The actuary may wish to view both sets of indications before selecting a final set of deductible rate relativities.

Another consideration is that the LER approach determines an average percentage credit that is applied to all policies with a certain deductible amount. In the earlier example, the credit for a $250 deductible is 13.5%. If the total policy premium is $3,000, then the credit for moving from full coverage to a $250 deductible is $405. Since the premium savings exceeds the amount of the deductible, the insured will be better off to select the deductible unless he or she expects to have multiple losses. A company may handle this circumstance in different ways. First, an insurer may implement a cap on the amount of dollar credit from the deductible; for example, the maximum dollar credit for moving from full coverage to a $250 deductible might be $200. Second, companies may calculate a different set of credits for different policies. For example, a homeowners insurer may have different deductible credits for low-, medium-, and high-valued homes. By segregating risks in this fashion, the chance of such reversals is minimized.

Finally, percentage deductibles address this issue since the amount of the deductible increases with the amount of insurance.

The examples did not address expenses, profit, etc. These issues are especially important for large deductible commercial policies and will be discussed in depth in Chapter 15.

SIZE OF RISK FOR WORKERS COMPENSATION

Many commercial lines products have relatively simple rating algorithms. Historically, workers compensation rating algorithms did not include a rating variable accounting for the size of the insured company. To account for expected differences in expense and loss levels for larger insureds, some workers compensation insurers vary the expense component for large risks, incorporate premium discounts or loss constants, or all of these.

Expense Component

As discussed in Chapter 7, commercial lines insurers typically use the All Variable Approach to determine the applicable expense provisions. The basic assumption of that approach is that underwriting expenses are a constant percentage of the premium charged. Since some expenses are fixed or nearly fixed, they do not vary greatly by the size of the policy. Consequently, policies with small average premium (i.e., small risks) will be undercharged and policies with large average premium (i.e., large risks) will be overcharged. Insurers may adjust for this in a few different ways.

First, workers compensation insurers may calculate a variable expense provision that only applies to the first $5,000 of standard premium.[40] Thus, the expenses on policies with standard premium greater than the $5,000 limit represent a smaller percentage of the total premium.

Second, insurers may charge an expense constant to all risks, which accounts for costs that are the same no matter the size of the policy, such as many underwriting and administrative expenses. Since the expense constant is a flat dollar amount, it is a decreasing percentage of written premium as the size of the policy increases.

Finally, workers compensation insurers apply a premium discount to policies with premium above a specified amount. The following table shows the calculation of the premium discount for a policy with standard premium of $400,000.

[40] Standard premium is a term defined by the National Council of Compensation Insurers (NCCI). In general, it is premium before application of premium discounts and expense constants, but the exact NCCI definition is beyond the scope of this text.

11.10 Workers Compensation Premium Discount Example

(1)		(2)	(3) Premium in Range	(4) Prod	(5) General	(6) Taxes	(7) Profit	(8) Total	(9) Expense Reduction	(10) Discount %	(11) Premium Discount
Premium Range											
$ -	-	$ 5,000	$ 5,000	15.0%	10.0%	3.0%	5.0%	33.0%	0.0%	0.0%	$ -
$ 5,000	-	$ 100,000	$ 95,000	12.0%	8.0%	3.0%	5.0%	28.0%	5.0%	5.4%	$ 5,130
$ 100,000	-	$ 500,000	$ 300,000	9.0%	6.0%	3.0%	5.0%	23.0%	10.0%	10.9%	$ 32,700
$ 500,000	-	above	-	6.0%	4.0%	3.0%	5.0%	18.0%	15.0%	16.3%	-
Standard Premium:			$ 400,000								$ 37,830

(3)= Min of [(2) - (1), Standard Premium-SumPrior(3)]
(9)= $(8_{\text{Row 1}})$-(8)
(10)= (9) / [1.0 -(6) - (7)]
(11)= (3) x (10)

In this procedure, the premium discount is calculated using a graduated expense discount scale and applying it to the premium in different layers. Column 3 shows the premium of $400,000 split into the premium ranges. Columns 4 through 7 show the applicable expense percentage for each type of expense. In the example, percentages for production and general expenses decrease for the larger premium ranges recognizing that some of the expenses do not vary by premium. Taxes and profit are assumed to be a constant percentage of premium and no reduction is applicable. Column 8 is the total expense and profit percentage by premium range, and Column 9 calculates the incremental change in the expense ratio for each premium range. The applicable premium discount is calculated by dividing the percentage reduction by 1.0 minus the expense percentages for taxes and profit; the division reflects the fact that the when the fixed expenses are reduced, the variable items associated with those expenses (i.e., taxes and profit) are reduced, too. The dollar discount is calculated by multiplying the premium in the range by the applicable discount percentage.

Loss Constants

Small workers compensation risks tend to have less favorable loss experience (as a percentage of premium) than large risks. There are several theories for this phenomenon. First, small companies generally have less sophisticated safety programs since they require a large amount of capital to implement and maintain. Second, small companies may also lack programs to help injured workers return to work. Finally, the premium for small insureds are either unaffected or only slightly impacted by experience rating, which results in lower rates for insureds with better than average loss experience and higher rates for insureds with worse than average loss experience.[41] Thus, small insureds may have less incentive to prevent or control injuries than large insureds.

When workers compensation insurers charge the same rate per exposure for small and large insureds, the premium will be inadequate for small companies and excessive for large companies. Historically, a loss constant has been added to the premium to equalize the final expected loss ratios between small and large insureds. The following table shows an example of the calculation.

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[41]Experience rating is discussed in detail in Chapter 15. Very small companies either may not be eligible for experience rating or the effect of experience rating may be limited through the use of credibility, or both.

11.11 Workers Compensation Loss Constant Example

(1)			(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Premium Range				Policies	Premium	Reported Loss	Initial Loss Ratio	Target Loss Ratio	Premium Shortfall	Loss Constant
$ 1	-	$ 2,500		1,000	$ 1,000,000	$ 750,000	75.0%	70.0%	$ 71,429	$ 71.43
$ 2,501	-	above		1,000	$ 5,000,000	$ 3,500,000	70.0%	70.0%	$ -	$ -

(6)= (5) / (4)
(7)= Given
(8)= [(5) / (7)] -(4)
(9)= (8) / (3)

In the example, the unadjusted expected loss ratios for small (premium less than or equal to $2,500) and large (premium greater than $2,500) risks are 75% and 70%, respectively. Assuming the insurer wants to achieve an expected loss ratio of 70% for both types of risks, an adjustment to the rate is necessary. Column 8 shows the amount of premium needed to decrease the small risk expected loss ratio to 70%, and is calculated by dividing the reported loss by the target loss ratio (to get the needed premium) and subtracting the premium without the loss constant. The loss constant is calculated by dividing the premium shortfall by the number of small risk policies.

With more sophisticated multivariate techniques, some insurers are adding a rating variable to account for the size of the risk. In such cases, the loss constant is no longer necessary.

INSURANCE TO VALUE (ITV)

For many property policies (e.g., homeowners), the policy limit corresponds to the value or replacement cost of the insured item, and the rates vary based on the policy limit chosen. The term insurance to value (ITV) is used to indicate how the level of insurance chosen relates to the overall value or replacement cost of the item. For example, if an item is insured to full value, then the amount of insurance equals the total value or replacement cost of the insured item. This section discusses the importance of ITV and addresses actions companies may take to ensure policies are insured to the appropriate level assumed in the rates.

Insurance to Value Example

To help understand the concept and the issues associated with ITV, consider the following example:

- Two homes worth $250,000 and $200,000 are each insured for the full amount.
- Expected claim frequency is assumed to be 1% for both homes.
- Expected losses are uniformly distributed.

That information yields the following expected size of loss distributions and rates for each home:

11.12 Calculations for a $250,000 Home

Size of Loss ($000s)	(1) Loss Distribution	(2) Average Reported Loss ($000s)
$ - <X <= $ 25	10.0%	$ 12.5
$ 25 <X <= $ 50	10.0%	$ 37.5
$ 50 <X <= $ 75	10.0%	$ 62.5
$ 75 <X <= $ 100	10.0%	$ 87.5
$ 100 <X <= $ 125	10.0%	$ 112.5
$ 125 <X <= $ 150	10.0%	$ 137.5
$ 150 <X <= $ 175	10.0%	$ 162.5
$ 175 <X <= $ 200	10.0%	$ 187.5
$ 200 <X <= $ 225	10.0%	$ 212.5
$ 225 <X <= $ 250	10.0%	$ 237.5
Total	100.0%	$ 125.0
(3) Frequency		1%
(4) Pure Premium ($000s)		$ 1.25
(5) Amount of Insurance ($000s)		$ 250.00
(6) Rate per $1,000		$ 5.00

11.13 Calculations for a $200,000 Home

Size of Loss ($000s)	(1) Loss Distribution	(2) Average Reported Loss ($000s)
$ - <X <= $ 25	12.5%	$ 12.5
$ 25 <X <= $ 50	12.5%	$ 37.5
$ 50 <X <= $ 75	12.5%	$ 62.5
$ 75 <X <= $ 100	12.5%	$ 87.5
$ 100 <X <= $ 125	12.5%	$ 112.5
$ 125 <X <= $ 150	12.5%	$ 137.5
$ 150 <X <= $ 175	12.5%	$ 162.5
$ 175 <X <= $ 200	12.5%	$ 187.5
Total	100.0%	$ 100.0
(3) Frequency		1%
(4) Pure Premium ($000s)		$ 1.00
(5) Amount of Insurance ($000s)		$ 200.00
(6) Rate per $1,000		$ 5.00

(Tot2)= (2) weighted by (1)
(4)= (Tot2) x (3)
(6)= [(4) / (5)] x $1,000

Based on this information, the expected pure premium for the $250,000 home is $1,250 (=$125,000 x 0.01). Assuming no expenses or profit, the appropriate premium is $1,250. More specifically, the rate is $5 per $1,000 of amount of insurance ($= (\$1{,}250/\$250{,}000) \times \$1{,}000$). Similarly, the expected pure premium for a $200,000 home insured to full value is $1,000 (=$100,000 x 0.01), and the appropriate rate is $5 per $1,000 of amount of insurance.

Now consider the case in which the $250,000 home is only insured for $200,000. The expected loss distribution remains unchanged, but the expected claim payment is limited to the amount of insurance for the policy (i.e., $200,000):

11.14 Calculations for a $250,000 Home Insured for $200,000

Size of Loss ($000s)	(1) Loss Distribution	(2) Reported Loss ($000s)	(3) Average Payment ($000s)
$ - < *X* <= $ 25	10.0%	$ 12.5	$ 12.5
$ 25 < *X* <= $ 50	10.0%	$ 37.5	$ 37.5
$ 50 < *X* <= $ 75	10.0%	$ 62.5	$ 62.5
$ 75 < *X* <= $ 100	10.0%	$ 87.5	$ 87.5
$ 100 < *X* <= $ 125	10.0%	$ 112.5	$ 112.5
$ 125 < *X* <= $ 150	10.0%	$ 137.5	$ 137.5
$ 150 < *X* <= $ 175	10.0%	$ 162.5	$ 162.5
$ 175 < *X* <= $ 200	10.0%	$ 187.5	$ 187.5
$ 200 < *X* <= $ 225	10.0%	$ 212.5	$ 200.0
$ 225 < *X* <= $ 250	10.0%	$ 237.5	$ 200.0
Total	100.0%	$ 125.0	$ 120.0
(4) Frequency			1%
(5) Pure Premium ($000s)			$ 1.20
(6) Amount of Insurance ($000s)			$ 200.00
(7) Rate per $1,000			$ 6.00

(Tot2)= (2) weighted by (1)
(Tot3)= (3) weighted by (1)
(5)= (Tot3) x (4)
(7)= [(5) / (6)] x $1,000

This demonstrates two problems associated with underinsurance. First, the insurance payment will not be sufficient to cover the full loss amount 20% of the time. Thus, the insured will not be returned to the pre-loss condition. Second, if the insurer assumes all homes are insured to full value and uses a rate of $5 per $1,000, then the premium will not be sufficient to cover the expected payments for a home that is underinsured. Therefore, the rates are not equitable.

It is important to note that the inequity in the rates is caused by the fact that the homes are not insured to the same level. If all homes are underinsured by the same percentage amount, then the resulting premium may not be adequate to cover all the losses, but the premium will be equitable. Over time, the base rate will adjust so that aggregate premium covers the aggregate losses at the actual level of ITV present in the book of business.

A key point is that the inequity and adequacy issues only exist because partial losses are possible. The following table shows a comparison if all claims are total losses:

11.15 Three Policies-Total Losses Only

	(1)	(2)	(3)
Full Value of Item ($000s)	$ 500	$ 500	$ 400
Amount of Insurance ($000s)	$ 500	$ 400	$ 400
Frequency	1%	1%	1%
Severity ($000s)*	$ 500	$ 400	$ 400
Pure Premium ($000s)	$ 5	$ 4	$ 4
Rate per $1,000	$ 10	$ 10	$ 10
Premium ($000s)	$ 5	$ 4	$ 4

*All losses are total losses.

In this case, the home that is underinsured (2) still results in a claim payment that is less than the full value of the item. However, the total premium collected is adequate and the rates are equitable.

Coinsurance Clause

Coinsurance implies that two or more parties are jointly participating in the insurance arrangement. In property insurance, an insurer may implement a coinsurance clause in which the two parties are the insurer and the insured. Basically, the insurer may require a minimum insurance to value (e.g., 80% of full value) or else payment on covered losses will be reduced proportionately by the amount of underinsurance.[42] The intent of the coinsurance requirement is to achieve greater equity among risks, though more so through the payment of losses than the adequacy of rates.

The following notation is used in the coinsurance calculations:

- I = indemnity received after loss
- L = amount of loss after deductible
- F = face value of policy (i.e., amount of insurance selected)
- V = value of property
- c = required coinsurance percentage
- a = apportionment ratio
- e = coinsurance penalty

Using this notation, the coinsurance requirement (cV) is the amount of coverage required such that no penalty is applied. The coinsurance apportionment ratio (a) is the relationship of the amount of insurance selected (F) to the coinsurance requirement (cV), and is the factor applied to the loss amount to calculate the indemnity payment:

$$a = \min\left[\frac{F}{cV}, 1.0\right].$$

[42] In some countries (e.g., the U.K.), this is known as the Principle of Averages.

The indemnity payment is given by the following basic formula:

$$I = L \times \frac{F}{cV}, \text{ where } I \le F \text{ and } I \le L.$$

The coinsurance penalty (e) is the amount that the indemnity payment is reduced by the application of the coinsurance clause. A reduction occurs when the following three conditions apply:

1. A non-zero loss has occurred (i.e., $L > 0$).
2. The face amount of insurance is less than the coinsurance requirement (i.e., $F < cV$).
3. The loss is less than the coinsurance requirement (i.e., $L < cV$).

The amount of the penalty is given by the following:

$$e = \begin{cases} L - I, & \text{if } L \le F \\ F - I, & \text{if } F < L < cV. \\ 0, & \text{if } cV \le L \end{cases}$$

To illustrate these points, consider a home valued at \$500,000 that is only insured for \$300,000 despite a coinsurance requirement of 80% (or \$400,000 in this case). Since the face value is \$300,000 a coinsurance deficiency exists and the apportionment ratio is 0.75 (=\$300,000 / \$400,000).

The following are the indemnity payments and coinsurance penalties for a \$200,000 loss:

$$I = L \times \frac{F}{cV} = \$200{,}000 \times \frac{\$300{,}000}{\$400{,}000} = \$150{,}000,$$

$$e = L\text{-}I = \$200{,}000\text{-}\$150{,}000 = \$50{,}000.$$

The following are the indemnity payments and coinsurance penalties for a \$300,000 loss:

$$I = L \times \frac{F}{cV} = \$300{,}000 \times \frac{\$300{,}000}{\$400{,}000} = \$225{,}000,$$

$$e = L\text{-}I = \$300{,}000\text{-}\$225{,}000 = \$75{,}000.$$

The following are the indemnity payments and coinsurance penalties for a \$350,000 loss:

$$I = L \times \frac{F}{cV} = \$350{,}000 \times \frac{\$300{,}000}{\$400{,}000} = \$262{,}500,$$

$$e = F\text{-}I = \$300{,}000\text{-}\$262{,}500 = \$37{,}500.$$

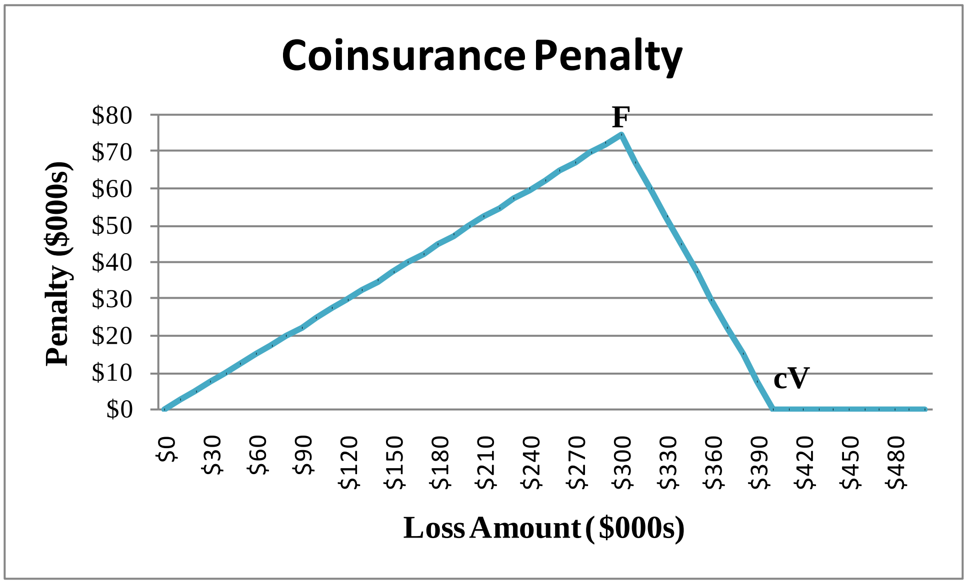
The following are the indemnity payments and coinsurance penalties for a $450,000 loss:

$$I = L \times \frac{F}{cV} = \$450{,}000 \times \frac{\$300{,}000}{\$400{,}000} = \$337{,}500, \text{ but } \$337{,}500 > F, \text{ so } I = F = \$300{,}000,$$

$$e = F\text{-}I = \$300{,}000\text{-}\$300{,}000 = \$0.$$

The following chart illustrates the magnitude of the coinsurance penalty for all loss values between $0 and $500,000 (i.e., the full value of the home):

11.16 Coinsurance Penalty by Loss Amount



This chart shows that the dollar coinsurance penalty increases linearly between $0 and the face amount, which is where the penalty is the largest. The penalty decreases for loss sizes between the face amount and the coinsurance requirement. There is no coinsurance penalty for losses larger than the coinsurance requirement, but the insured suffers a penalty in that the payment does not cover the total loss.

For the coinsurance mechanism to work appropriately in the event of a loss, it is important that the value of the insured property can be established so that the coinsurance penalty can be accurately calculated.

Varying Rates Based on ITV Level

A coinsurance penalty clause corrects for inequity caused by two homes being insured to different levels of ITV by adjusting the indemnity payment in the event of a loss. Another way to achieve equity is to calculate and use rates based on the level of ITV. Returning to Tables 11.12 through 11.14, the indicated rate per $1,000 of insurance was the same for the two homes insured to full value (i.e., $5 per $1,000 of insurance) and higher for the underinsured home (i.e., $6 per $1,000 of insurance). If those indicated rates were used, the premium would have been equitable and no coinsurance penalty would have been necessary.

A rate can be calculated for any face amount of insurance given the expected frequency, the size of loss distribution, and the full value of the property. Use the following notation:

- f = frequency of loss
- $s(L)$ = probability of loss of a given size
- V = maximum possible loss (which may be unlimited for some insurance)
- F = face value of policy

The formula to determine the rate is the expected indemnity payment divided by the face value of the policy.[43] Given a set of empirical losses, the rate is as follows:

$$\text{Rate} = \frac{f \times \left[\sum_{L=1}^{F} Ls(L) + F \times (1.0 - \sum_{L=1}^{F} s(L)) \right]}{F}.$$

Given a distribution of losses, the rate is as follows:

$$\text{Rate} = \frac{f \times \left[\int_{0}^{F} Ls(L)dL + F \times (1.0 - \int_{0}^{F} s(L)dL) \right]}{F}.$$

Assuming partial losses are possible, the rate per amount of insurance decreases as the face value gets closer to the value of the insured item. The rate of change of that decrease will vary depending on the shape of the loss distribution:

- Left-skewed distribution (i.e., small losses predominate): the rate will decrease at a decreasing rate as the policy face value increases.
- Uniform distribution (i.e., all losses equally likely): the rate will decrease at a constant rate as the policy face value increases.
- Right-skewed distribution (i.e., large losses predominate): the rate will decrease at an increasing rate as the policy face value increases.

Under the rate approach (as opposed to the coinsurance penalty), the coinsurance is really thought to be any portion of the loss that exceeds the face value should the insured choose a face value less than the full value of the property. The major difficulty with the rate approach is determining the loss distribution.

Insurance to Value Initiatives

The homeowners policy in the U.S. typically settles losses based on replacement cost, subject to the policy limit. One feature of the policy that encourages insurance to full value is guaranteed replacement cost (GRC). This policy feature allows replacement cost to exceed the policy limit if the property is 100% insured to value and, in some cases, subject to annual indexation. In the 1990s, large catastrophes such as Hurricane Andrew and the Oakland fires changed the dynamics of the construction industry and

[43] The amount of insurance is frequently shown in $100 or $1,000 increments.

insurers were faced with replacement costs far in excess of insured values. The industry responded by changing the policy feature to cap the replacement cost (e.g., 125% of policy limit).

In more recent years, the property insurance industry has implemented other means to encourage insurance to full value. For example, insurers are using more sophisticated property estimation tools. Previously these tools were crude estimators that considered a limited number of inputs when calculating value (e.g., square footage and number of rooms) and updated the value at renewal according to broad geographic indices. Today's component indicator tools consider customized features of the home (e.g., granite countertops, hardwood floors, age of plumbing and electricity); moreover, these same tools are used to estimate insured value at renewal as well.

By increasing the amount of insurance on underinsured homes to the level of ITV assumed in the rates, companies are able to generate additional premium without increasing rates. Since homeowners loss distributions tend to be left-skewed (i.e., small losses predominate), the increased premium is more than the additional losses generated from this action. As the insureds receive increased coverage, they are generally more accepting of the increased premium than if rate increases were implemented.

In addition to property estimation tools, the industry has made better use of property inspections, indexation clauses, and education of insureds. As with any major change to insurance company operations, the actuaries need to estimate the effect of any ITV initiative on overall results.

SUMMARY

The preceding two chapters outlined basic classification ratemaking techniques designed to achieve equity among insureds. This chapter outlined some other methods used by actuaries to determine equitable rates based on a few important risk characteristics.

Territorial ratemaking involves establishing territorial boundaries and then deriving rate relativities for those territories. Because location tends to be heavily correlated with other factors and many locations have very sparse data, special techniques are required to estimate the risk for each geographic unit. Once a geographic estimator is calculated for each unit, additional techniques are applied in order to combine the units into territories. Rate relativities for the territories can be derived using the methods described in the previous rate classification chapters.

Increased limit factors are difficult to price as large losses tend to be rare. Actuaries can price increased limit factors for a given limit of insurance as the severity of losses at that limit divided by the severity of losses at the basic limit. Actuaries may use empirical data or fitted data for these calculations. In some cases, actuaries may use multivariate analysis or other advanced techniques (e.g., ISO Mixed Exponential).

Pricing deductibles is similar to increased limits except that the loss is censored below the deductible rather than above the policy limit. Actuaries generally calculate loss elimination ratios, which represent the portion of the loss eliminated by the deductible. This approach does not account for the varying behavior of insureds that self-select different amounts of insurance; consequently, actuaries may supplement their loss elimination ratio analysis with multivariate analysis that does capture behavioral differences.

Workers compensation rating algorithms have not traditionally considered size of risk as a rating variable yet insurers generally agree that the loss experience between small and large risks is different. To incorporate this difference in the rates, insurers use expense adjustments and loss constants in the rating algorithms.

For many property lines of business, such as homeowners, it is important that the property be insured to the value assumed in the rates. When insureds underinsure their properties, they risk not being fully covered in the event of a loss; moreover, this condition creates inequity compared to policies that are insured to full value. Insurers address this inequity by either reducing covered losses through a coinsurance clause or by adjusting rates according to the degree of underinsurance. Insurers have also implemented various initiatives to ensure that individual risks are insured to the appropriate value.

KEY CONCEPTS FOR CHAPTER 11

1. Territorial ratemaking
   a. Establishing territorial boundaries
      i. Defining basic geographic units
      ii. Creating geographic estimators
      iii. Smoothing geographic estimators
      iv. Combining units based on clustering techniques
   b. Calculating territorial rate relativities

2. Increased limit factors
   a. Limited Average Severity
      i. Uncensored losses
      ii. Censored losses
   b. Fitted data approach
   c. Other considerations
   d. Multivariate approach
   e. ISO mixed exponential approach

3. Deductible LER approach
   a. Discrete approach
   b. Fitted data approach
   c. Practical considerations

4. Workers compensation size of risk
   a. Expense component
   b. Loss constants

5. Insurance to Value (ITV)
   a. Importance of ITV
   b. Coinsurance
      i. Penalty
      ii. Varying rates based on ITV level
   c. ITV initiatives

CHAPTER 12: CREDIBILITY

Prior chapters covered ratemaking techniques that use historical data to develop actuarial estimates of future loss experience. According to the Law of Large Numbers, as the volume of similar, independent exposure units increases, the observed experience will approach the "true" experience, and for a sufficiently large number, the observed experience will equal the "true" experience. The experience of any one insured can vary significantly from year to year. By insuring a large number of independent risks, the experience of the entire group becomes more stable and can be more accurately predicted. Unfortunately, the volume of data used for overall ratemaking or classification ratemaking may not always be fully sufficient to produce accurate and stable rates, and the actuary can consider supplementing the data with additional information. The science of credibility in ratemaking addresses how to blend the actuarial estimate based on observed experience with one or more sets of related experience in order to improve the estimate of expected values.

This chapter covers:

- Methods for measuring credibility in an actuarial estimate[44]
- Desirable qualities for the complement of credibility
- Methods (and examples) for determining the complement of credibility in both first dollar and excess ratemaking
- A brief commentary on credibility when using statistical multivariate ratemaking techniques

NECESSARY CRITERIA FOR MEASURES OF CREDIBILITY

The first step in utilizing credibility is to determine the reliability of the actuarial estimate based on observed experience. Assuming homogenous risks, the amount of credibility given to the observed experience, commonly denoted by Z, should meet the following three basic criteria:

1. Z must be greater than or equal to zero (i.e., no negative credibility) and less than or equal to 1.00 (i.e., capped at fully credible).
2. Z should increase as the number of risks underlying the actuarial estimate increases (all else being equal).
3. Z should increase at a non-increasing rate.

METHODS FOR MEASURING CREDIBILITY IN AN ACTUARIAL ESTIMATE

As defined in Actuarial Standard of Practice (ASOP) Number 25 "Credibility Procedures Applicable to Accident and Health, Group Term Life, and Property/Casualty Coverages" (ASOP No. 25, 1996, p. 1), credibility is "a measure of the predictive value in a given application that the actuary attaches to a particular body of data."

The actuary should be familiar with and consider various methods for determining the credibility of a particular body of data. Two commonly discussed credibility methods are classical credibility and

[44] This chapter will not cover the application of credibility within experience rating calculations.

Bühlmann credibility. Both methods involve explicit calculation of a measure of credibility used to blend subject experience and related experience. A third method, Bayesian analysis, introduces related experience into the actuarial estimate in a probabilistic measure. In other words, the method does not explicitly calculate a measure of credibility.

These three methods are covered extensively in other actuarial texts; this chapter is meant to provide an overview.

Classical Credibility Approach

The classical credibility approach, commonly called limited fluctuation credibility, is the most frequently used method in insurance ratemaking. The goal of classical credibility is to limit the effect that random fluctuations in the observations have on the risk estimate.

In this approach, a value of credibility (*Z*) is calculated and used to assign weights to the observed experience (also known as subject experience or base statistic) and to some related experience in the following linear expression:

$$\text{Estimate} = \text{Z x Observed Experience} + (1.0 - \text{Z}) \text{ x Related Experience.}$$

Let *Y* represent the total number of claims, and *S* represent the total amount of losses. The actuary first determines the expected number of claims, (*E*(*Y*), required for the observed experience to be considered fully credible (*Z*=1.00).

The observed experience is considered fully credible when the probability (*p*) is high that the observed experience will not differ significantly from the expected experience by more than some arbitrary amount (*k*). Stated in probabilistic terms:

$$\Pr\left[(1-k)E(S) \le S \le (1+k)E(S)\right] = p.$$

According to the Central Limit Theorem,

$$\frac{S\text{-}E(S)}{\sqrt{Var(S)}} \sim N(0,1).$$

Therefore, the probabilistic expression above can be transformed as follows:

$$\Pr\left[\frac{(1\text{-}k)E(S) - E(S)}{\sqrt{Var(S)}} \le \frac{S\text{-}E(S)}{\sqrt{Var(S)}} \le \frac{(1+k)E(S) - E(S)}{\sqrt{Var(S)}}\right] = p.$$

Since the normal distribution is symmetric about its mean, this is equivalent to:

$$\left[\frac{(1+k)E(S) - E(S)}{\sqrt{Var(S)}}\right] = z_{(p+1)/2},$$

where $z_{(p+1)/2}$ is the value in the Standard Normal table for specified values $(p+1)/2$.

Consider the following simplifying assumptions about the observed experience:

- Exposures are homogeneous (i.e., each exposure has the same expected number of claims).
- Claim occurrence is assumed to follow a Poisson distribution; therefore, it follows that the expected number of claims, $E(Y)$, equals the variance, Var(Y).
- There is no variation in the size of loss (i.e., constant severity).

Given those assumptions, the expression above can be simplified to:

$$\left[\frac{kE(Y)}{\sqrt{E(Y)}}\right] = z_{(p+1)/2}.$$

By squaring both sides of the equation and rearranging the terms, the expected number of claims needed for full credibility can be expressed as:

$$E(Y) = \left(\frac{z_{(p+1)/2}}{k}\right)^2.$$

For example, an actuary may regard the loss experience as fully credible if there is a 90% probability that the observed experience is within 5% of its expected value. This is equivalent to saying there is a 95% probability that the observed losses are no more than 5% above the mean. In the Standard Normal table, the 95th percentile is 1.645 standard deviations above the mean; therefore, the expected number of claims needed for full credibility is:

$$E(Y)=\left(\frac{1.645}{0.05}\right)^2=1{,}082.$$

If the number of observed claims is equal to or greater than the standard for full credibility (1,082 in the example above), the measure of credibility (Z) is 1.00:

$$Z = 1.00 \text{ where } Y \geq E(Y).$$

If the number of observed claims is less than the standard for full credibility, the square root rule is applied to calculate Z:

$$Z = \sqrt{\frac{Y}{E(Y)}} \text{ where } Y < E(Y).$$

In the example above, if the observed number of claims is 100, Z is calculated as:

$$Z = \sqrt{\frac{100}{1{,}082}} = 0.30.$$

The square root formula, with the inclusion of the maximum of 1.0, does meet the three criteria discussed earlier.

In some cases, the actuary may prefer to have a full credibility standard based on the number of exposures rather than the number of claims. The exposure standard is calculated by dividing the number of claims needed for full credibility by the expected frequency.

The following table shows the number of claims and exposures needed for full credibility using example values for *k* and *p*:

12.1 Example Full Credibility Standards

(1) *k*	(2) *p*	(3) $z_{(p+1)/2}$	(4) Number of Claims for Full Credibilty	(5) Projected Frequency	(6) Number of Exposures for Full Credibility
5%	90%	1.645	1,082	5.0%	21,640
10%	90%	1.645	271	5.0%	5,420
5%	95%	1.960	1,537	5.0%	30,740
10%	95%	1.960	384	5.0%	7,680
5%	99%	2.575	2,652	5.0%	53,040
10%	99%	2.575	663	5.0%	13,260

(3)= From Normal Distribution Table
(4)= [(3) / (1)] ^ 2
(6)= (4) / (5)

If the actuary rejects the assumption that there is no variation in the size of losses, the number of claims needed for observed data to be considered fully credible is as follows:

$$E(Y) = \left(\frac{z_{(p+1)/2}}{k} \right)^2 x \left(1 + \frac{\sigma_s^2}{\mu_s^2} \right),$$

where $\frac{\sigma_s^2}{\mu_s^2}$ is the coefficient of variation squared.

Removing the other simplifying assumptions will also alter the calculation for the full credibility standard; appropriate derivations and formulae are beyond the scope of this text. More in-depth discussion can be found in “Credibility” (Mahler and Dean 2001).

Simple Example

Calculate the credibility-weighted pure premium estimate assuming the following:

- The standard for full credibility is set so that the observed value is to be within +/-5% of the true value 90% of the time.
- The actuary assumes exposures are homogeneous, claim occurrence follows a Poisson distribution, and there is no variation in claim costs.
- The observed pure premium of $200 is based on 100 claims.
- The pure premium of the related experience is $300.

Based on the specified values of *k* and *p*, the corresponding value on the Standard Normal table is 1.645. The claim count standard for full credibility is therefore:

$$E(Y) = \left(\frac{1.645}{0.05}\right)^2 = 1{,}082.$$

Z is calculated by the square root rule as:

$$Z = \text{Min}\left[\sqrt{\frac{100}{1{,}082}}, 1.00\right] = 0.30.$$

The credibility-weighted pure premium estimate is $270 (=0.30 x $200 + (1-0.30) x $300).

Comments on Approach

This approach has three main advantages. First, it is the most commonly used and is therefore generally accepted. Second, the data required for this approach is readily available. Finally, the computations are very straightforward. The main disadvantage of this approach is that the derivation involves making several simplifying assumptions that may not be true in practice (e.g., no variation in the size of losses).

The actuary should consider the advantages and disadvantages above and determine whether this approach is appropriate for the particular ratemaking analysis.

Bühlmann Credibility

Bühlmann credibility is commonly referred to as least squares credibility since the goal of this approach is to minimize the square of the error between the estimate and the true expected value of the quantity being estimated. When using least squares credibility, the credibility-weighted estimate is defined as:

$$\text{Estimate} = Z \text{ x Observed Experience} + (1.0 - Z) \text{ x Prior Mean.}$$

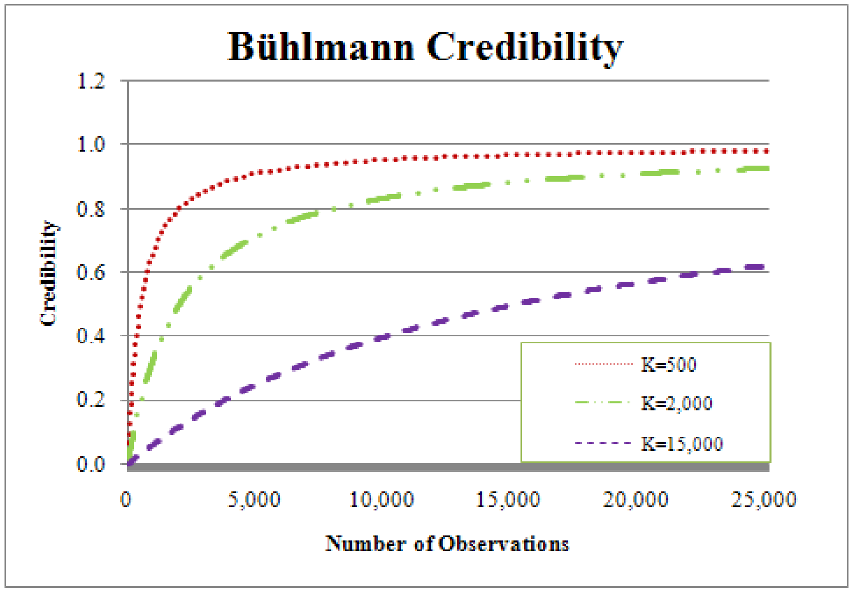
Whereas classical credibility considered related experience, this formula considers a prior mean, which reflects the actuary’s a priori assumption of the risk estimate.

In least squares credibility, Z is defined as follows:

$$Z = \frac{N}{N + K}.$$

N represents the number of observations, and K is the expected value of the process variance (EVPV) divided by the variance of the hypothetical means (VHM). The ratio K can be described more simply as the ratio of the average risk variance and the variance between risks. In practice, K can be difficult to calculate and the method of calculation is beyond the scope of this text. Chart 12.2 shows the sensitivity of the derived credibility for three different values of K.

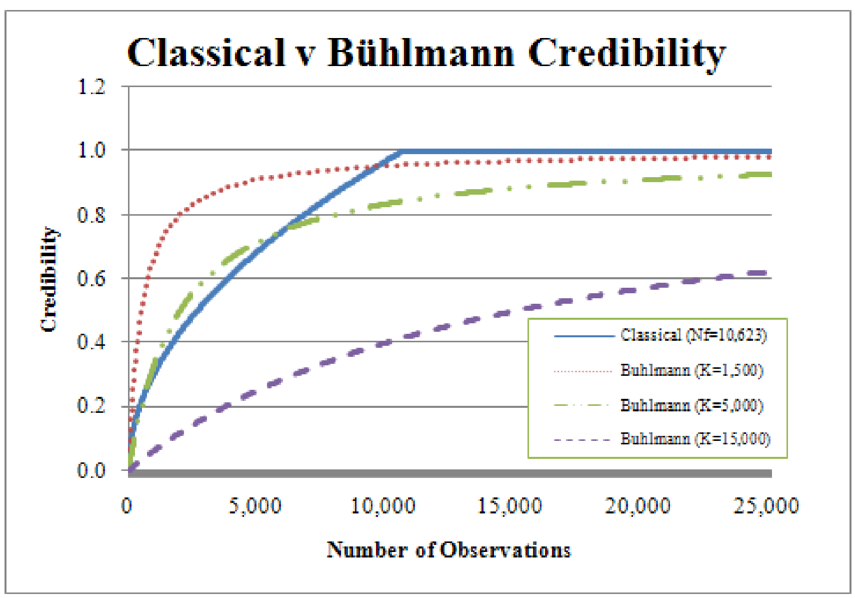
12.2 Comparison of Z for Different Values of K



Since K is a constant for a given situation, the credibility will meet the criteria listed earlier in the chapter. The chart demonstrates this visually.

For Bühlmann credibility, Z approaches 1.0 asymptotically as N gets larger, whereas the classical credibility measure equals 1.0 at the point the number of claims or exposures equals the full credibility standard (denoted N_f) and thereafter. Chart 12.3 shows a comparison of the credibility at different numbers of observations (N) under classical and Bühlmann approaches.

12.3 Comparison of Credibility Values



For these specific values of N_f and K and for a relatively small number of observations, the Bühlmann credibility estimate is closest to the classical credibility estimate when K equals 5,000 (i.e., the line with dashes and dots is close to the solid line). As the number of observations gets larger, the Bühlmann credibility estimate is closest to the classical credibility estimate when K equals 1,500 (i.e., the dotted line). Many practitioners using classical credibility make simplifying assumptions—for example, they ignore the variation in the size of losses and assume that the risks in the subject experience are homogeneous. If these same assumptions are made with least squares credibility, then VHM = 0 (this is because all of the exposures have exactly the same claim distribution). When VHM = 0, then $Z = 0$ and no credibility is assigned to the observed experience.

The Bühlmann credibility formula has a number of assumptions, summarized as follows:

- (1.0-Z) is applied to the prior mean.
- The risk parameters and risk process do not shift over time.
- The expected value of the process variance (EVPV) of the sum of N observations increases with N.
- The variance of the hypothetical means (VHM) of the sum of N observations increases with N.

Simple Example

Calculate the Bühlmann credibility-weighted estimate assuming the following:

- The observed pure premium is \$200 based on 21 observations.
- The expected value of the process variance (EVPV) is 2.00.
- The variance of the hypothetical means (VHM) is 0.50.
- The prior mean is \$225.

Given that information,

$$K = \frac{\text{EVPV}}{\text{VHM}} = \frac{2.00}{0.50} = 4.00,$$

and

$$Z = \frac{21}{21 + 4.00} = 0.84;$$

consequently,

$$\text{Credibility-weighted Pure Premium } = 0.84 \text{ x } \$200 + (1 - 0.84) \text{ x } \$225 = \$204.$$

Comments on Approach

While not as common as classical credibility, least squares credibility is used within the insurance industry and is generally accepted. The major challenge of this approach is the determination of the expected value of the process variance and the variance of the hypothetical means. Like classical credibility, least squares credibility is also based on a set of simplifying assumptions that need to be evaluated to confirm that this approach is suitable for the given situation.

Bayesian Analysis

The third class of credibility analysis is based on Bayesian theory. In Bayesian analysis there is no specific calculation of the *Z* parameter, but a distributional assumption must be made. Bayesian analysis is based on the fundamental notion that the prior estimate is adjusted to reflect the new information. The new information is introduced into the prior estimate in a probabilistic manner, via Bayes Theorem. This differs from least squares credibility where the new information is introduced into the prior estimate via the credibility weighting. Note that due to the greater complexities of its probabilistic nature, Bayesian analysis is not used as commonly in practice as Bühlmann credibility.

It is interesting to note that Bühlmann or least squares credibility is the weighted least squares line associated with the Bayesian estimate. In certain special mathematical situations, the Bayesian analysis estimate is equivalent to the least squares credibility estimate.

DESIRABLE QUALITIES OF A COMPLEMENT OF CREDIBILITY

As discussed earlier, the basic formula for calculating the credibility-weighted actuarial estimate using classical credibility is: [45]

$$\text{Estimate} = Z \text{ x Observed Experience} + (1 - Z) \text{ x Related Experience.}$$

Once the credibility of the observed data is determined, the next step is to select the related experience. This is commonly referred to as the "complement of credibility." According to ASOP 25:

> The actuary should use care in selecting the related experience that is to be blended with the subject experience. Such related experience should have frequency, severity, or other determinable characteristics that may reasonably be expected to be similar to the subject experience. If the proposed related experience does not or cannot be adjusted to meet such criteria, it should not be used. The actuary should apply credibility procedures that appropriately reflect the characteristics of both the subject experience and the related experience.

The complement of credibility can often be more important than the observed data. For example, if the observed experience varies around the true experience with a standard deviation equal to its mean, it will probably receive a very low credibility. Therefore, the majority of the rate (in this context, expected loss estimate) will be driven by the complement of credibility.

[45] Theoretically when an actuary determines credibility based on the Bühlmann approach, the complement of credibility should be the prior mean. Even so, actuaries have used other related experience when Bühlmann credibility is used.

In "Complement of Credibility" (Boor 2004, pp. 7-8), Boor gives desirable qualities for a complement of credibility:

1. Accurate
2. Unbiased
3. Statistically independent from the base statistic
4. Available
5. Easy to compute
6. Logical relationship to base statistic.

Rates should have as low an error variance as possible around the future expected losses being estimated. A complement of credibility that helps achieve this is considered accurate.

The complement should not be routinely higher or lower than the observed experience. Said another way, the differences between the complement and the observed experience should average to zero over time. If this is not the case, the complement is biased and the actuary needs to determine whether or not the bias is material.

The distinction between accurate and unbiased is important. An unbiased statistic varies randomly around the following year's losses over many successive years, but it may not be close. An accurate statistic may be consistently higher or lower than the following year's losses, but it is always close.

The complement should also be statistically independent from the base statistic. If it is not independent, then any error in the base statistic can be compounded.

The data required to compute the complement should be readily available. If it is not, then the complement of credibility is not practical. The calculations should also be relatively easy to perform and understand. This is particularly important when the actuary must provide justification to a third party (e.g., regulator) for approval.

Finally, the complement should have an explainable relationship to the observed experience. If there is a logical relationship, it is much easier to support the use of the complement to any third party reviewing the actuarial justification.

METHODS FOR DEVELOPING COMPLEMENTS OF CREDIBILITY

There are a variety of complements used in practice. The remainder of this chapter describes and evaluates different methods for developing complements of credibility for both first dollar ratemaking and excess ratemaking. First dollar ratemaking is performed on products that cover claims from the first dollar of loss (or after some small deductible) up to some limit. Personal automobile, homeowners, workers compensation, and professional liability insurance are good examples of first dollar products. In first dollar ratemaking, historical losses are used for the base statistic, and they are generally the same magnitude as the true expected losses. In contrast to first dollar products, excess insurance products cover claims that exceed some high attachment point. Personal umbrella policies, large deductible commercial policies, and excess reinsurance are good examples of excess products.

First Dollar Ratemaking

Boor describes six commonly used methods for developing complements for first dollar ratemaking:

- Loss costs of a larger group that includes the group being rated
- Loss costs of a larger related group
- Rate change from the larger group applied to present rates
- Harwayne's method
- Trended present rates
- Competitor's rates

The complements are discussed in terms of pure premium ratemaking. Several of the methods can be used with loss ratio methods by replacing the exposure units with earned premium.

Loss Costs of a Larger Group that Include the Group being Rated

This complement considers the experience of a larger group to which the subject experience belongs. The following are a few examples that may apply:

- A multi-state insurer may use data from all states in the region to supplement the experience of the state being reviewed.
- A medical malpractice insurer may use the experience of all primary care physicians to supplement the experience of primary care pediatricians.
- An auto insurer may use the data of all insureds ages 16-19 to supplement the experience of 16-year-olds.
- An insurer may use data from a longer-term period to credibility-weight observed experience that is short-term.

Consider the following data (adapted from Boor 2004, p 11) and the possibilities for a complement of credibility to the observed experience, the latest year pure premium from Rate Group A, Class 1 (= $50).

12.4 Data from a Larger Group

Rate Group	Class	Latest Year Exposures	Latest Year Pure Premium	Latest 3 Years Exposures	Latest 3 Years Pure Premium
A	1	100	$ 50	250	$ 64
	2	300	$ 67	850	$ 65
	3	400	$ 48	1,100	$ 50
	Subtotal	800	$ 55	2,200	$ 57
B	Subtotal	600	$ 48	1,700	$ 32
C	Subtotal	1,000	$ 72	2,800	$ 86
D	Subtotal	1,600	$ 94	5,600	$ 87
Total	Total	4,000	$ 74	12,300	$ 74

Some of the obvious candidates for complement of credibility are the three-year pure premium for Rate Group A, Class 1; the one- or three-year pure premium for Rate Group A; and the one- or three-year pure premium for the total of all experience. While not shown, another option is the total of all Class 1 experience across all rate groups.

The following comments summarize the advantages and disadvantages of complement of credibility candidates.

- Using the three-year pure premium of Rate Group A, Class 1 experience (i.e., $64) is problematic. The one-year subject experience comprises over one-third the exposures of the three-year complement experience, thus it is most likely not independent. Additionally, the large difference between the one-year pure premium ($50) and the three-year pure premium ($64) suggests the three-year data may be biased (i.e., changes in loss costs may have occurred that makes the older data less relevant).
- Using the total of all experience combined ranks better with respect to independence as the latest year of Rate Group A, Class 1 is only a small portion of the total experience (100 out of 4,000 exposures). A comparison of the total one and three-year pure premiums suggests the total experience has low process variance; however, the difference between the one-year Rate Group A, Class 1 pure premium ($50) and the one-year total pure premium ($74) implies a bias may be present.
- Using the one-year Rate Group A experience appears to be the best of the given options. The Rate Group A data should reflect risks that are more similar to Class 1. Comparing the one-year pure premium ($55) and three-year pure premium ($57) suggests it has a low process variance. Also, the one-year result is not significantly different than the one-year Rate Group A, Class 1 result ($50), which suggests little bias.
- The data is not readily available to use the Class 1 data from all rate groups combined. Otherwise, it is possible that would be a reasonable option.

Evaluation

Because the complement is based on a greater volume of data, it is likely to have a lower process variance than the subject experience. However, as discussed in the classification ratemaking chapters, the actuary tries to subdivide data into homogenous groups. The fact that the subject experience has been split out of the larger group suggests that the actuary believes the subject experience is different than the larger group. If this is the case, then the larger group is likely a biased estimator of the subject experience. The actuary may be able to make an adjustment to reduce this bias.

The complement can be constructed to include or exclude the subject experience. If the complement excludes the subject experience, then it is likely to be independent. If the subject experience is included, the key is to ensure it does not dominate the group. For example, regional data, including the state, should not be used as a complement if the state represents a large portion of the regional data.

The loss cost data of the larger group is typically available and the loss cost is easy to compute. As long as all the risks in the larger group have something in common, there is a logical connection between the complement and the subject experience.

Loss Costs of a Larger Related Group

Instead of using the loss cost of the larger group to which the subject experience belongs, the actuary may use the loss costs of a separate but similar, large group. For example, a homeowners insurer may use the contents loss experience from the owners forms to supplement the contents experience for the condos form.

Evaluation

This method is similar to the large group complement. It is generally biased though the magnitude and direction of bias are unknown. If the actuary can adjust the related experience to match the exposure to loss in the subject experience, the bias can be reduced. In the example mentioned above, the actuary needs to consider how the exposure to loss for condos differs from owned homes and adjust the experience accordingly.

Since the complement does not contain the subject experience, this lack of dependence may make it a better choice than the first method described.

The data for this method is likely readily available and the calculations should be the same as those used to derive the base statistic. Adjustments made to the related experience to correct for bias may be difficult to explain. If the groups are closely related, then the complement will have a logical relationship to the base statistic.

Rate Change from the Larger Group Applied to Present Rates

The loss costs of a larger related group may be a biased complement of credibility. This third approach mitigates this problem by using the rate change indicated for a larger group applied to the current loss cost of the subject experience, rather than using the larger group's loss costs directly.

The complement (C) can be expressed as:

$$C = \text{Current Loss Cost of Subject Experience} \times \left(\frac{\text{Larger Group Indicated Loss Cost}}{\text{Larger Group Current Average Loss Cost}} \right).$$

As way of example, assume the following:

- Current loss cost of subject experience is \$200.
- Indicated loss cost of larger group is \$330.
- Current average loss cost of larger group is \$300.

Then the complement of credibility, to be blended with the subject experience loss cost, is calculated as follows:

$$C = \$200 \times \frac{\$330}{\$300} = \$220.$$

Evaluation

Even when the overall loss costs for the subject experience and the larger group are different, this complement is largely unbiased. Assuming the rate changes are relatively small, this complement is likely to be accurate over the long term. The level of independence depends on the size of the subject experience relative to the larger group. The data for this method is most likely readily available, and the calculations are very straightforward. In many instances it is logical that the rate change indicated for a larger related group is indicative of the rate change for the subject experience.

Harwayne's Method

Harwayne's Method is used when the subject experience and related experience have significantly different distributions, and the related experience requires adjustment before it can be blended with the subject experience. A prime application of Harwayne's method is when the subject experience is within a specific geographical area (e.g., a state), and the desired complement of credibility considers related experience in other geographical areas. The other geographical areas (e.g., other states) have distinctly different cost levels than the subject experience due to circumstances such as legal environment and population density. For example, the pure premium may be 10% higher for every risk in a complement state compared to the otherwise identical risks in the subject state; in this case, the actuary should adjust the loss costs from that state prior to using them as a complement of credibility.

In this application of Harwayne's method, the complement of credibility is determined using countrywide data (excluding the base state being reviewed), but the countrywide data is adjusted to remove overall differences between states. The following example illustrates the steps necessary to calculate the complement for class 1 of state A.

12.5 Harwayne Method

State	Class	Exposure	Losses	Pure Premium
A	1	100	$ 250	2.50
	2	125	$ 500	4.00
	Subtotal	225	$ 750	3.33
B	1	190	$ 600	3.16
	2	325	$ 1,500	4.62
	Subtotal	515	$ 2,100	4.08
C	1	180	$ 500	2.78
	2	450	$ 1,800	4.00
	Subtotal	630	$ 2,300	3.65
All	1	470	$ 1,350	2.87
	2	900	$ 3,800	4.22
	Total	1,370	$ 5,150	3.76

The first step is to calculate the average pure premium for state A:

$$\overline{L_A} = \frac{100 \times 2.50 + 125 \times 4.00}{100 + 125} = 3.33.$$

The next step is to calculate the average pure premium for states B and C based on the state A exposure distribution by class:

$$\hat{L}_B = \frac{100 \times 3.16 + 125 \times 4.62}{100 + 125} = 3.97,$$

$$\hat{L}_C = \frac{100 \times 2.78 + 125 \times 4.00}{100 + 125} = 3.46.$$

Adjustment factors are calculated by dividing the average pure premium for state A by the reweighted average pure premium for B and C:

$$F_{\text{B}} = \frac{\overline{L}_{\text{A}}}{\hat{L}_{\text{B}}} = \frac{3.33}{3.97} = 0.84,$$

$$F_{\text{C}} = \frac{\overline{L}_{\text{A}}}{\hat{L}_{\text{C}}} = \frac{3.33}{3.46} = 0.96.$$

These adjustment factors are applied to the class 1 pure premium in states B and C, respectively, to adjust for the difference in loss costs by state A. The adjusted loss costs for class 1 in states B and C, respectively, are:

$$\hat{L}_{1,\text{B}} = \overline{L_{1,\text{B}}} \times F_{\text{B}} = 3.16 \times 0.84 = 2.65,$$
$$\hat{L}_{1,\text{C}} = \overline{L_{1,\text{C}}} \times F_{\text{C}} = 2.78 \times 0.96 = 2.67.$$

The complement of credibility (C) is then calculated by combining the adjusted Class 1 loss costs by state into a single Class 1 loss cost according to the proportion of class 1 risks in each state:

$$C = \frac{\hat{L}_{1,\text{B}} \times X_{1,\text{B}} + \hat{L}_{1,\text{C}} \times X_{1,\text{C}}}{X_{1,\text{B}} + X_{1,\text{C}}} = \frac{2.65 \times 190 + 2.67 \times 180}{190 + 180} = 2.66.$$

Evaluation

The complement derived from this method is unbiased as it adjusts for the distributional differences. The use of multi-state data generally implies the complement is reasonably accurate as long as there is sufficient countrywide data to minimize the process variance. Also, since the subject experience and related experience consider data from different states, the complement is considered mostly independent.

The data for the complement is usually available but the computations can be time-consuming and complicated. While the complement bears a logical relationship to the subject experience, the complement may be harder to explain because of the computational complexity.

Trended Present Rates

In cases where there is no larger group to use for the complement, actuaries may rely on the current rates as the best available proxy for the indicated rate. Typically, two adjustments are made before using the current rates to make this a suitable alternative.

First, insurers do not always implement the rate that is indicated (reasons for this are discussed in Chapter 13). Thus, the current rates should be adjusted to what was previously indicated rather than what was implemented.

Second, changes in loss cost level may have occurred between the time the current rates were implemented and the time of the review. Sources of such changes may be monetary inflation, distributional shifts, safety advances, etc. The current rate therefore should be adjusted for any applicable trends. The actuary should select an appropriate annual loss trend and apply it from the original target effective date of the current rates to the target effective date of the new rates. The original target effective date of the current rates is used as the "trend from" date rather than the actual effective date to account for the fact that changes are not always implemented when planned and rates may remain in effect for shorter or longer than planned. By using the target effective date, the actuary is trending from the date assumed in the prior actuarial analysis.

Combining these two adjustments, the complement of credibility (*C*) that is used to supplement the indicated rate is calculated as follows:

$$C = \text{Present Rate} \times \text{Loss Trend Factor} \times \frac{\text{Prior Indicated Loss Cost}}{\text{Loss Cost Implemented with Last Review}}.$$

By way of example, assume the following:

- Present average rate is $200.
- The selected annual loss trend is 5%.
- The rate change indicated in the last review was 10%, and the target effective date was January 1, 2011.
- The rate change implemented with the last review was 6%, and the actual effective date was February 1, 2011.
- The proposed effective date of the next rate change is January 1, 2013.

Before calculating the complement of credibility, the loss trend length must be measured. This is the length from the target effective date of the last rate review (January 1, 2011) to the target effective date of the next rate change (January 1, 2013), or two years.

Then the complement of credibility is calculated as follows:

$$C = \$200 \times (1.05)^2 x \frac{1.10}{1.06} = \$229.$$

This procedure can also be used to calculate a complement for an indicated rate change factor when using the loss ratio approach:

$$C = \frac{\text{Loss Trend Factor}}{\text{Premium Trend Factor}} \times \frac{\text{Prior Indicated Rate Change Factor}}{\text{Prior Implemented Rate Change Factor}}.$$

Evaluation

The accuracy of this complement depends largely on the process variance of the historical loss costs. That is why it is used primarily for indications with voluminous data. This complement is unbiased since pure trended loss costs (i.e., no updating for more recent experience) are unbiased. This complement may or may not be independent depending on the historical experience used to determine the subject experience and complement. For example, if the complement comes from a review that used data from years 2007 through 2010, and the subject experience is based on data from 2008 through 2011, then the two are not independent.

The data required is readily available, the calculations are very straightforward, and the approach is easily explainable.

Competitors' Rates

New or small companies with small volumes of data often find their own data too unreliable for ratemaking. In such cases the actuary may use the competitors' rates as a complement. The rationalization is that if the competitors have a much larger number of exposures, the competitors' statistics have less process error.

Evaluation

An actuary must consider that competitors' manual rates are not only based on the competitors' loss costs but also reflect marketing considerations, judgment, and the effects of the regulatory process—all of which can introduce inaccuracy to the rates. Competitors may also have different underwriting and claim practices than the subject company, which creates bias that may be difficult to quantify. The competitors' rates will be independent of the company data.

While the calculations may be straightforward, the data needed for this complement may be difficult or time-consuming to obtain. Even with the potential differences between competitors, the rates of a similar competitor bear a logical relationship and are generally accepted as a complement by regulators. This complement is often considered the only viable alternative.

Excess Ratemaking

Excess ratemaking usually deals with volatile and low volumes of data so the complement chosen is often more important than the subject experience. Complements for excess ratemaking are structured around the special problems of excess ratemaking. Typically there are very few claims in the excess layers; consequently, actuaries try to predict the volume of excess loss costs using loss costs below the attachment point. Losses for some lines of business (e.g., liability) may also be slow to develop, and inflation inherent in excess layers is different (usually higher) than that of the total limits experience.

Boor describes four methods that can be used to determine the complement of credibility for excess ratemaking analyses:

- Increased limits analysis
- Lower limits analysis
- Limits analysis
- Fitted curves

The first three methods use available loss data and increased limits factors to calculate the complement of credibility. The last method relies on historical data to fit curves, and the complement is calculated from the distribution.

Increased Limits Factors (ILFs)

Actuaries use this first method when data is available for ground-up losses through the attachment point (i.e., losses have not been truncated at any point below the bottom of the excess layer being priced). Increased limits factors are used to adjust losses capped at the attachment point to produce an estimate of losses in the specific excess layer.

The complement is defined as follows:

$$C = L_A \times \left(\frac{\text{ILF}_{A+L} - \text{ILF}_A}{\text{ILF}_A} \right) = L_A \times \left(\frac{\text{ILF}_{A+L}}{\text{ILF}_A} - 1.0 \right),$$

where

- L_A are the losses capped at the attachment point A;
- ILF_A is the increased limits factor for the attachment point A;
- ILF_{A+L} is the increased limits factor for the sum of the attachment point A and the excess insurer's limit of liability L.

For example, calculate the complement of credibility for the excess layer between $500,000 and $750,000 (i.e., $250,000 of coverage in excess of $500,000). Assume the losses capped at $500,000 are $2,000,000 and the following increased limits factors apply:

12.6 ILFs

Limit of Liability	Increased Limits Factor
$ 100,000	1.00
$ 250,000	1.75
$ 500,000	2.50
$ 750,000	3.00
$ 1,000,000	3.40

The complement of credibility is calculated as follows:

$$C = \$2,000,000 \times \left(\frac{3.00}{2.50} - 1.0 \right) = 400,000.$$

Evaluation

If the subject experience has a different size of loss distribution than that used to develop the increased limits factors, then the results of this procedure will be biased. This is particularly relevant as the increased limits factors may be based on industry data rather than the insurer's own data. Despite the issues with the accuracy, this is often the best available estimate.

The error with this approach is not the process error but rather the parameter error associated with the selection of the increased limits factors. Thus, the error associated with this estimate tends to be independent of the error associated with the base statistic.

This procedure requires increased limits factors—preferably industry factors—and ground-up losses that have not been truncated below the attachment point. To the extent that information is available, the procedure is practical. In terms of acceptability, however, this estimate is more logically related to the data below the attachment point (which is used for the projection) than to the data in the layer, and this may be controversial.

Lower Limits Analysis

The complement discussed above uses losses capped at the attachment point to estimate the losses in the excess layer being priced. If those losses are too sparse to be reliable, the actuary may prefer to use losses capped at a limit lower than the attachment point. This lower limit can often be the basic limit.

The formula for this complement is:

$$C = L_d \times \left(\frac{\text{ILF}_{A+L} - \text{ILF}_A}{\text{ILF}_d} \right),$$

where

- L_d are the losses capped at the lower limit, *d;*
- ILF_A is the increased limits factor for the attachment point *A;*
- ILF_d is the increased limits factor for the lower limit, *d*.
- ILF_{A+L} is the increased limits factor for the sum of the attachment point *A* and the excess insurer's limit of liability *L* (i.e., this sum represents the top of the excess layer being priced).

Note that the first excess procedure is a special case of this procedure where the lower limit, *d*, is equal to the attachment point.

For example, calculate the complement of credibility for the layer between \$500,000 and \$750,000. Assume the losses capped at \$250,000 are \$1,500,000, and the increased limits factors from Table 12.6 apply. The complement of credibility is calculated as follows:

$$C = \$1{,}500{,}000 \times \left(\frac{3.00 - 2.50}{1.75} \right) = \$428{,}571.$$

Evaluation

It is difficult to determine whether this is more or less accurate than the previously discussed complement. Intuitively, this complement will be more biased as the differences in size of loss distributions will be exacerbated when using losses truncated at lower levels. On the other hand, using losses capped at lower limits may increase the stability of the estimate. Like the previous complement, the error associated with this complement is generally independent of the error of the base statistic.

Insurers generally code losses capped at basic limits for statistical reporting purposes. Losses capped at the attachment point are generally important for accounting, too. If some other lower limit is chosen, the data may not be as available. The calculations are no more difficult than the previously discussed complement, and this complement suffers the criticism of being more logically related to the lower limits losses rather than the losses in the layer being priced.

Limits Analysis

The previous approaches work well when losses capped at a single point are available, but sometimes they are not. Primary insurers generally sell policies with a wide variety of policy limits. Some of the individual policy limits fall below the attachment point, and some extend beyond the top of the excess layer. The implication is that each policy's limit and increased limit factor needs to be considered in the calculation of the complement.

For this approach the actuary analyzes the policies at each limit of coverage separately. The actuary calculates the estimated losses in a given layer using the premium volume and expected loss ratio in that layer. Then the actuary performs an increased limits factor analysis on each first dollar limit's loss costs separately. The formula for the complement of credibility is as follows:

$$C = \mathrm{LR} \times \sum_{d \geq A} P_d \times \frac{\left(\mathrm{ILF}_{\min(d,A+L)} - \mathrm{ILF}_A\right)}{\mathrm{ILF}_d},$$

where

- LR= Total limits loss ratio,
- P_d= Total premium for policies with limit d.
- The ILFs have the same meaning as previously discussed.

The following shows an example of the calculation of the expected loss for the layer between $500,000 and $750,000 assuming a total limits loss ratio of 60%.

12.7 Example Calculation for Limits Approach

(1) Limit of Liability (*d*)	(2) Premium	(3) Expected Loss Ratio	(4) Expected Total Losses	(5) ILF @ *d*	(6) ILF @ *A*	(7) ILF @ *A+L*	(8) % Loss In Layer	(9) Expected Loss in Layer
$ 100,000	$ 1,000,000	60.0%	$ 600,000	1.00	2.50	3.00	0.0%	$ -
$ 250,000	$ 500,000	60.0%	$ 300,000	1.75	2.50	3.00	0.0%	$ -
$ 500,000	$ 200,000	60.0%	$ 120,000	2.50	2.50	3.00	0.0%	$ -
$ 750,000	$ 200,000	60.0%	$ 120,000	3.00	2.50	3.00	16.7%	$ 20,040
$ 1,000,000	$ 75,000	60.0%	$ 45,000	3.40	2.50	3.00	14.7%	$ 6,615
Total	$ 1,975,000		$ 1,185,000					$ 26,655

(4)= (2) x (3)

(8)= if d <= A then 0.0%; if $A < d$ <= $A+L$ then [(5)- (6)]/(5); if d > $A+L$ then [(7)- (6)]/(5)

(9)= (4) x (8)

Evaluation

This complement is biased and inaccurate to the same extent as the prior two complements, and it involves relying on the additional assumption that the expected loss ratio does not vary by limit.

Because this type of excess loss analysis is typically undertaken by reinsurers that do not have access to the full loss distribution, this may be the only method available. It is more time-consuming to compute, but the calculations are straightforward. It generates the same criticism as the other methods because it is not based on actual data from the layer being priced.

Fitted Curves

As discussed in the increased limits section in Chapter 11, actual loss distributions can be very volatile, especially in the tail of the distribution (i.e., the higher losses). As such, any estimates based directly on actual data are subject to inaccuracy due to the volatility. Actuaries may fit curves to the actual data to smooth out the volatility and to extrapolate the distribution to higher limits.

Once the curve is fitted, the techniques described in Chapter 11 can be used to determine the expected losses in the layer being priced. The following formula is used to determine the percentage of the curve's total losses that are expected in the excess layer:

$$\%\text{ Losses in Layer }(A, A+L) = \frac{\int_{A}^{A+L} (x-A)\, f(x)dx + \int_{A+L}^{\infty} Lf(x)dx}{\int_{-\infty}^{\infty} xf(x)dx}.$$

This percentage can be applied to the total limits loss costs to determine the expected losses in the layer.

Evaluation

This complement tends to be less biased and more stable than the other excess methods, assuming that the fitted curve replicates the general shape of the actual data. This approach tends to be significantly more accurate than the others when there are relatively few claims in the higher layers.

Because the curve-fitting process involves the underlying data, it can be heavily dependent on the existence or non-existence of larger claims. Thus, the error associated with a complement developed using this approach will tend to be less independent than complements determined from the other approaches.

This approach tends to be the most computationally complex and requires data that may not be readily available. The complement developed using this approach tends to be the most logically related to the losses in the layer than the others as the data is more fully used. However, the computational complexity may make it difficult to communicate.

CREDIBILITY EXAMPLES

This chapter provided different techniques that can be used to blend an actuarial estimate based on observed experience with related experience in order to improve the estimate of expected values. The actuarial estimate and the complement can take many forms, as demonstrated in the appendices. The actuarial estimate in Appendix A is the indicated rate change from the subject experience. It is credibility weighted with the trended present rates indicated rate change. Appendix B credibility weights the statewide ex-catastrophe pure premium with a regional ex-catastrophe pure premium. The actuarial estimate in Appendix C is the indicated rate change from the subject experience. It is credibility-weighted with the countrywide indicated rate change. Appendix E, a univariate classification analysis, credibility weights the indicated pure premium relativities with the current pure premium relativities. Before blending these two sets of relativities, each is normalized such that the weighted average relativity is 1.00.

CREDIBILITY WHEN USING STATISTICAL METHODS

When performing a multivariate classification analysis using statistical techniques such as generalized linear models (as discussed in Chapter 10), statistical diagnostics provided with the model results are used to gauge to what extent the model results are meaningful given the data provided. Examples of statistical diagnostics include standard errors of the parameter estimates and standardized deviance tests (e.g., Chi-Square or F-test), as well as practical tests such as consistency of model results over time. The modeler considers this information when selecting the final model structure and the final rate differentials. Statistical methods also provide diagnostics that inform the modeler of the overall appropriateness of the model assumptions (e.g., the link function or error term selected). Examples of such diagnostics include deviance residual plots and leverage plots.

Typically, the results of a multivariate classification analysis are not credibility-weighted with traditional (univariate) actuarial estimates. Some research has been conducted around incorporating Bayesian analysis into the statistical modeling process (for example, the use of hierarchical models), but this is beyond the scope of this text.

SUMMARY

The purpose of this chapter was to provide a broad overview of the credibility procedures used in ratemaking. As discussed, the credibility-weighted actuarial estimate is expressed by the following formula:

$$\text{Estimate} = Z \text{ x Observed Experience} + (1 - Z) \text{ x Related Experience.}$$

The classical credibility method and least squares credibility method prescribe different procedures for developing the credibility measure, *Z*. Classical credibility is effective in developing results that minimize the fluctuation from the related experience. Least squares credibility is used to generate accurate rates. In Bayesian analysis, there is no specific calculation of *Z*; it is based on the fundamental notion that the prior estimate is adjusted to reflect the new information, which is introduced into the prior estimate in a probabilistic manner. Once the method for developing the credibility measure is selected, the actuary should be careful to understand and appropriately document any simplifying assumptions that are made.

The chapter also provided desirable qualities for the selection of the related experience, referred to as the complement of credibility. Finally, the chapter outlined several methods for developing the complement of credibility for both first dollar and excess ratemaking, and evaluated each method within the context of specified evaluation criteria.

KEY CONCEPTS IN CHAPTER 12

1. Criteria for measures of credibility

2. Methods for determining credibility
    a. Classical credibility
    b. Bühlmann credibility
    c. Bayesian analysis

3. Desirable qualities for the complement of credibility
    a. Accurate
    b. Unbiased
    c. Independent
    d. Available
    e. Easy to calculate
    f. Logical relationship to the base statistic

4. Methods for determining the complement of credibility
    a. First dollar ratemaking
        i. Loss costs of a larger group that includes the group being rated
        ii. Loss costs of a larger related group
        iii. Rate change from the larger group applied to present rates
        iv. Harwayne's method
        v. Trended present rates
        vi. Competitors' rates

    b. Excess ratemaking
        i. Increased limits analysis
        ii. Lower limits analysis
        iii. Limits analysis
        iv. Fitted curves

5. Credibility when using statistical modeling methods

CHAPTER 13: OTHER CONSIDERATIONS

Recall that the fundamental insurance equation is:

$$\text{Premium} = \text{Losses} + \text{LAE} + \text{UW Expenses} + \text{UW Profit}.$$

The preceding chapters have focused on techniques to calculate a set of indicated rates or indicated changes to current rates to produce premium that is expected to cover all costs (i.e., the loss, loss adjustment expense, and underwriting expense) and achieve the targeted underwriting profit. These indications represent the actuary's best cost-based estimate of rates to charge, given the available information. Even when the company is very confident in the analysis, the company may elect to implement rates and rating variable differentials other than those indicated.

This chapter explores other considerations company management should make, along with the cost-based rate indications, to determine what rates to charge in practice. More specifically, the following considerations are covered in this chapter:

- Regulatory constraints
- Operational constraints
- Marketing considerations

REGULATORY CONSTRAINTS

The U.S. property/casualty insurance industry is highly regulated, and for the most part, the regulation is executed by the individual states both through state law and state regulatory agencies. The amount of regulatory scrutiny can vary significantly by jurisdiction and by insurance product. For example, the amount of scrutiny tends to be high for personal automobile insurance since the majority of car owners have to meet state-mandated financial responsibility requirements by purchasing this type of coverage. Similarly, workers compensation insurance is required for most U.S. employers to indemnify employees injured on the job. Because employee welfare is so important, workers compensation is a heavily regulated line of business in every state. In contrast, the amount of oversight tends to be lower for other types of commercial insurance (e.g., directors and officers insurance), which may not be compulsory and are generally purchased by more sophisticated buyers.

U.S. insurance rate regulation generally requires that insurers file proposed manual rates with the appropriate state insurance department or similar regulatory body. The filing requirements vary considerably by jurisdiction and product. Some regulation requires the regulator's approval of the new rates before the company can use them. Other regulation merely requires a copy of the manual rates to be on file with the regulator. In some extreme cases, the regulator may promulgate the rates to be used by the carriers but allow a specified range of deviation from these rates.

In Canada, insurance rate regulation is executed by the individual provinces. Similar to the U.S., the type of regulation varies considerably among the jurisdictions and by insurance product. For the personal automobile product, some provinces require approval of filed rates and others operate more on open competition. A few provinces have a government insurer for compulsory liability coverages, but allow open competition for other coverages.

The United Kingdom has much less rigid insurance rate regulation than the U.S., relying more on competitive pressures to "regulate" the market. Even so, the U.K. also places some pricing restrictions on what insurers can and cannot do. For example, European Union (E.U.) legislation regarding personal automobile insurance requires that, in the U.K., insurers must be prepared to demonstrate that the gender relativities in their rates be proportionate to underlying risk relativities (i.e., insurers should not deviate considerably from actuarial indications regarding gender relativities). Currently, there is also a debate in the E.U. and U.K. about potential legislation that might restrict the treatment of age as a rating variable in a similar way to gender.

In many of the Latin American markets, the regulation of insurance rates is focused more on rate adequacy (i.e., ensuring that insurers collect the minimum premium necessary to meet their obligations) than equity among classifications. Generally, Latin American rating plans are unsophisticated. One exception is Brazil, in which carriers utilize a wider range of rating variables on some products (e.g., personal automobile) and rates are required to be filed with the regulators for approval.

In many developing markets like India, rate regulation is heavier on compulsory coverages (e.g., personal automobile liability), but other insurance products are deregulated and operate more on open competition. Despite the rate deregulation, the rating plans are still relatively simple because of the lack of credible data collected.

Examples of U.S. Regulatory Constraints

In some jurisdictions around the world, insurance regulation may preclude the use of certain actuarially indicated rates or rate differentials. The following are U.S. examples of regulatory constraints that may cause a company to implement rates that are different from those indicated by its ratemaking analyses.

Some jurisdictions have regulations that limit the amount of an insurer's rate change. These limitations may pertain to either the overall average rate change for the jurisdiction or to the change in premium for any individual customer or group of customers, or both. For example, a jurisdiction may prohibit a rate change that generates an overall premium increase greater than 25% and/or a rate change that results in a significant number of existing customers getting an increase greater than 30%. In fact, the limitation could apply to any insureds seeing an increase larger than 30%. To the extent that the indicated rates exceed either of these thresholds, the proposed rate change will not comply with regulation and will not be approved by the regulator.

While some jurisdictions may not specifically limit the amount of the rate change, they may have different regulatory requirements depending on the magnitude of the requested change. For example, the regulatory authority may require a company to provide written notice to all insureds or hold a public hearing in the event a proposed rate change exceeds some specified threshold. In such cases, a company may decide to implement a rate change that is less than the threshold to avoid the extra requirements.

Some regulations prohibit the use of particular characteristics for rating, even though the characteristics may be demonstrated to be statistically strong predictors of risk. The use of insurance credit score for underwriting or rating personal lines insurance (e.g., personal automobile or homeowners) is a good example. It is widely accepted that an individual's insurance credit score is a strong predictor of risk in personal lines. Where allowed, many companies charge higher premium for individuals with poor credit scores than for individuals with good credit scores. However, because credit score is often perceived to be correlated with certain socio-demographic variables, some jurisdictions have placed limitations on the use of credit and some have banned the use of credit altogether.

Some regulations prescribe the use of certain ratemaking techniques. For example, the state of Washington currently requires that multivariate classification analysis be used to develop rate relativities if insurance credit score is used to differentiate premium in personal automobile insurance. Other states prescribe the use of a certain method for incorporating investment income in the derivation of the target underwriting provision (further discussion of this is beyond the scope of this text).

In addition, there are times when the company actuary and the regulator have differing views on certain ratemaking assumptions, which often leads to a different set of indicated rates. For example, a regulator may disagree with the method the actuary used to calculate loss trend, or may disagree with the trend selected. There are numerous examples of differences of opinion, and these differences have to be recognized when finalizing what rates are to be charged in practice. In particular, there may be a cost (e.g., delayed implementation of new rates, requirement of specialized staff resources) associated with negotiating with the regulator to resolve such differences.

Regardless of the company's rate indications, a company must charge rates that comply with the applicable state regulations. Fortunately, the regulations typically apply uniformly to all companies; therefore, all companies face the same limitations. A company can take a variety of actions with respect to regulatory restrictions:

- A company can take legal action to challenge the regulation.
- A company may decide to revise underwriting guidelines in order to limit the amount of business written at what it considers to be inadequate rate levels, although some locations require insurers to "take all comers" for personal lines.
- A company may change marketing directives to try to minimize new applicants whose rates are thought to be inadequate. For instance, an insurer might concentrate its advertising on areas in which it believes the rate levels to be adequate.
- In the case of banned or restricted usage of a particular variable (e.g., insurance credit scores), a company can use a different allowable rating variable (e.g., payment history with the company) that it believes can explain some or all of the effect associated with the restricted variable.

OPERATIONAL CONSTRAINTS

Operational constraints can make it difficult or undesirable for a company to implement the actuarially indicated rate change. Operational constraints can include items like systems limitations and resource constraints.

In order for premium quotes to be generated automatically when a customer's information is collected, rating algorithms, rates, and rate differentials need to be programmed. Base rates and rate differentials (e.g., relativities or addends) can usually be changed easily. For many companies, however, modifying the structure of the rating algorithm can require significant systems changes. The complexity of the change depends largely on two factors:

- The extent of the structural changes (e.g., the number of rating variables, the number of levels within each rating variable, how the rating variables are applied in the rating algorithm)

- The number of systems (e.g., quotation, claims, monitoring, etc.) impacted by the rate change

For example, prior to the 1990s many U.S. personal automobile carriers charged the same rate for all adults over the age of 30. Even after analysis clearly indicated that the risk varied significantly within the adult class (e.g., drivers over the age of 65 are relatively higher risk drivers than adult drivers under the age of 65), many companies did not immediately implement a more refined classification plan because the change required significant systems changes.

In addition, the implementation of a new rating variable may require data that has not been previously captured. While it may be possible to obtain this data from a third-party vendor, it is often necessary to get this data directly, either through a questionnaire sent to insureds or by visually inspecting the insured item. These approaches can necessitate additional insurance company staff with unique skills. For example, new building techniques (e.g., tie-down roofs) have enabled homes to better withstand strong winds. Because companies were not previously offering lower rates for such features, the information was not tracked by most companies. As a result, trained inspectors were necessary to ascertain the existence of these features. If such inspectors are not readily available, implementation may not be feasible immediately.

When an operational constraint arises, a cost-benefit analysis can be performed to help determine the appropriate course of action. Consider the example of a systems constraint that prohibits the introduction of a new or refined rating variable. The cost of implementing the change is the tangible cost associated with modifying the system. The benefit of implementing the change is the incremental profit that can be generated by charging more accurate rates, and presumably attracting more appropriately priced customers (i.e., the calculation of incremental profit should consider any estimated change in the distribution of business caused by the change). If the cost outweighs the benefit, then it may not be wise to pursue the change unless there are additional intangible benefits that could not be quantified.

The following is an example of a very simple cost-benefit analysis. Assume a ratemaking analysis identifies that a risk characteristic accounts for a 10% difference in projected ultimate losses and expenses between Class A and Class B. The characteristic is not currently reflected in the rates; consequently, both classes are charged a rate of $1,050. (Note that this average rate reflects a target profit provision of 5.2%.) Using the current average rate, Class A risks will be more profitable than Class B risks.
Table 13.1 depicts the number of risks for each class, as well as the projected costs, current rates, and achieved profit for each class.

13.1 Calculation of Profit (Current Rates)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
						Actual Profit	
Class	# Risks	Projected Losses & Expenses	Projected Losses & Expenses per Risk	Current Rate per Risk	Target Profit %	$	%
A	50,000	$ 45,000,000	$ 900	$ 1,050		$ 7,500,000	14.3%
B	1,000,000	$ 1,000,000,000	$ 1,000	$ 1,050		$ 50,000,000	4.8%
Total	1,050,000	$ 1,045,000,000	$ 995	$ 1,050	5.2%	$ 57,500,000	5.2%

(3) = (2) / (1)
(6) = [(4) - (3)] x (1)
(7) = (6) / [(4) x (1)]

If the rating variable is implemented, the company can decrease the rate for Class A and increase the rate for Class B in line with the difference in expected costs. In other words, instead of charging $1,050 for all risks, Refined Company can charge Class A risks $950 and Class B risks $1,055. Assuming no change in the risks insured, there will be no change in the total profit but the cross-subsidy will be eliminated. This can be seen in Table 13.2.

13.2 Calculation of Profit (After Rate Change)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
						Actual Profit	
Class	# Risks	Projected Losses & Expenses	Projected Losses & Expenses per Risk	Current Rate per Risk	Target Profit %	$	%
A	50,000	$ 45,000,000	$ 900	$ 950		$ 2,500,000	5.3%
B	1,000,000	$ 1,000,000,000	$ 1,000	$ 1,055		$ 55,000,000	5.2%
Total	1,050,000	$ 1,045,000,000	$ 995	$ 1,050	5.2%	$ 57,500,000	5.2%

(3) = (2) / (1)
(6) = [(4) - (3)] x (1)
(7) = (6) / [(4) x (1)]

If this action is taken, the company will likely write more Class A risks and possibly fewer Class B risks. Assuming the change results in 25% more Class A business and no change in Class B business, the profit projections are as follows:

13.3 Calculation of Profit (After Rate Change and Distributional Shift)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Class	# Risks	Projected Losses & Expenses	Projected Losses & Expenses per Risk	Current Rate per Risk	Target Profit %	Actual Profit $	Actual Profit %
A	62,500	$ 56,250,000	$ 900	$ 950		$ 3,125,000	5.3%
B	1,000,000	$ 1,000,000,000	$ 1,000	$ 1,055		$ 55,000,000	5.2%
Total	1,062,500	$ 1,056,250,000	$ 994	$ 1,049	5.2%	$ 58,125,000	5.2%

(3) = (2) / (1)
(6) = [(4) - (3)] x (1)
(7) = (6) / [(4) x (1)]

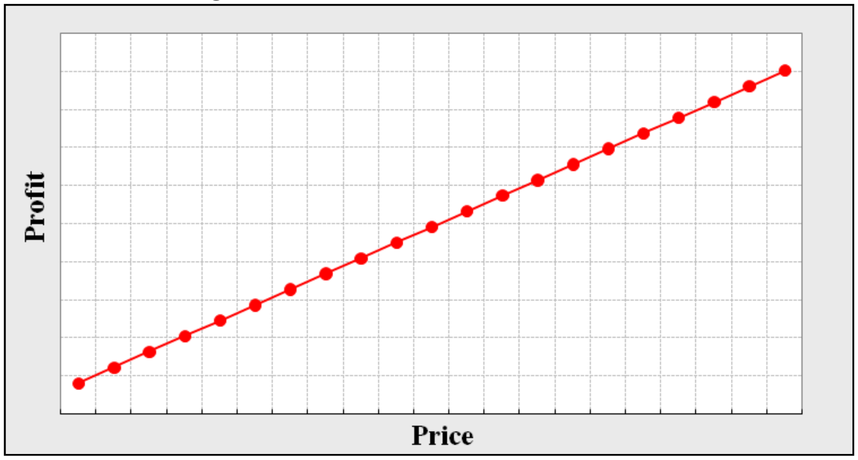
Based on this simple analysis and the assumptions inherent in it, implementation of the rating variable will generate an additional $625,000 (= $58,125,000 - $57,500,000) in profits over the time horizon estimated. This figure should be compared to the cost of making the change to help determine the appropriate course of action.

The standard ratemaking analysis used to develop the indicated rate differentials generally does not account for costs necessary to implement systems changes. When such costs are considered, the indicated rates may be different. There may also be other costs associated with this change (e.g., changes in staffing for the underwriting department to handle the increased number of Class A insureds). This is a crude example of a cost-benefit analysis and is based solely on tangible benefits (e.g., profit) and costs (e.g., system costs). Some projects may require significantly more complex calculations and may include intangible benefits (e.g., goodwill). The amount of rigor necessary for any cost-benefit analysis should vary depending on the relative costs, benefits, and uncertainty associated with the project.

MARKETING CONSIDERATIONS

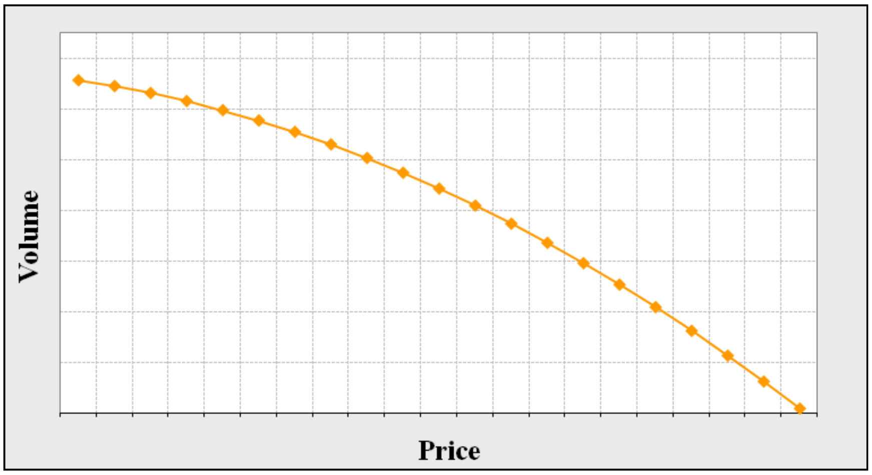
Prior to this chapter, the focus has been on using traditional actuarial techniques to determine the premium at which a company is able to cover costs and earn the target underwriting profit without any regard to the company's ability to sell the product. When assuming the number of policies is fixed, the relationship between price and profit can be illustrated as follows:

13.4 Profit Assuming Fixed Volume



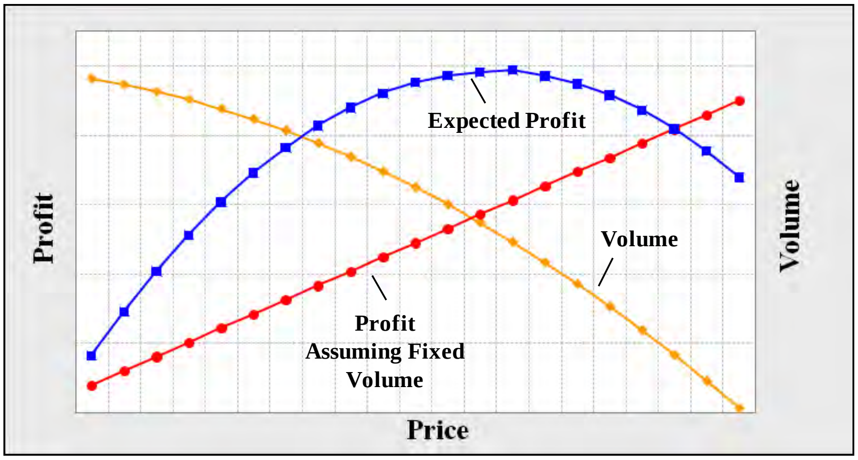
In other words, profit increases as price increases. Of course, profit is only achieved if the product is actually sold. Additionally, there is a certain amount of fixed cost (e.g., building costs) that does not vary significantly regardless of the number of policies sold. For these reasons, companies should consider the demand for the product being priced. The following figure depicts a typical demand curve, demonstrating that the demand for a product decreases as the price increases.

13.5 Sample Demand Curve



To determine the true expected profitability, the two curves should be considered simultaneously. As shown in Figure 13.6, expected profit as a function of price is an arc-shaped curve.

13.6 Expected Profit Considering Demand



Total profit increases as price increases until the price at which the impact of lost business outweighs the benefit associated with higher prices on the business that remains. In other words, overall profitability will suffer if the prices are set too high. This does not mean that the traditional actuarial rate indication is incorrect. The traditional actuarial techniques described thus far determine rates without regard to whether or not the product will be purchased. Prior to finalizing a rate change, the insurance company should consider both the cost-based rate indication and the marketing conditions.

When contemplating marketing considerations, companies often categorize insureds into new and renewal business. New business comprises potential customers who are currently uninsured or insured with another carrier. Renewal business refers to existing customers of the insurance product being analyzed. These groups are generally analyzed separately as the purchasing behavior and expected profitability of each group can be quite different. Some factors that commonly affect an insured's propensity to renew an existing product or purchase a new product are:

- **Price of competing products**: If insureds know another company offers the same product at a substantially lower price, they are likely to purchase the competing product.
- **Overall cost of the product**: If the insurance product is relatively cheap in general (e.g., as a percent of disposable income), then insureds are less likely to spend time shopping for a cheaper product. On the other hand, if the product is costly, insureds are more likely to compare prices to determine any potential savings.
- **Rate changes:** Significant increases (or decreases) in premium for an existing policy can cause existing insureds to believe there may be better options available.
- **Characteristics of the insured**: A large established law firm may be less sensitive to the price of its commercial package policy than a sole practitioner. A young policyholder may shop (and subsequently change insurers) more frequently than an older policyholder.
- **Customer satisfaction and brand loyalty:** Poor claims handling or a bad customer service experience may cause existing insureds to be dissatisfied and explore other options.

It should be noted that these factors may be more relevant for personal lines insureds than for larger commercial lines insurance purchasers. Commercial entities generally have less access to competitive price information and may have a vested interest to stay with an existing carrier based on service.

Traditional Techniques for Incorporating Marketing Considerations

Traditionally, marketing considerations have been incorporated judgmentally in the ratemaking process. Using this approach, the decision-maker considers the traditional actuarial rate indication along with marketing information to judgmentally determine the set of rates that should be implemented. The marketing information may include:

- Competitive comparisons
- Close ratios, retention ratios, growth
- Distributional analysis
- Dislocation analysis

Competitive Comparisons

One way for an insurer to study its competitive position is to compare its premium to the premium charged by one or more competitors. The availability and accuracy of competitor premium information varies by jurisdiction and by product. Even in the U.S. where companies are routinely required to file rating manuals, all the information necessary to accurately determine the premium charged by competitors can be difficult to obtain. For example, U.S. commercial lines companies typically adjust the manual rate via schedule and experience rating (which will be discussed in more detail in Chapter 15). In U.S. personal lines, estimating a competitor's premium can be difficult if the competitor makes extensive use of risk placement to vary the rate charged. For example, U.S. personal lines companies utilize underwriting tiers that essentially function as an additional rating variable, but the guidelines or algorithms that allocate risks into tiers are not always publicly available.

In more sophisticated, less regulated markets (e.g., the U.K.), rate manuals may not be readily available, and rates may be changed as frequently as daily. Companies in these markets may rely on obtaining competitive price information from brokers, questioning potential or existing customers about price information, or surveying Web-based quoting engines.

In spite of the challenges in obtaining accurate competitor price information, it is still a valuable endeavor for companies to compare their own premium to their best estimate of their main competitors' premium.

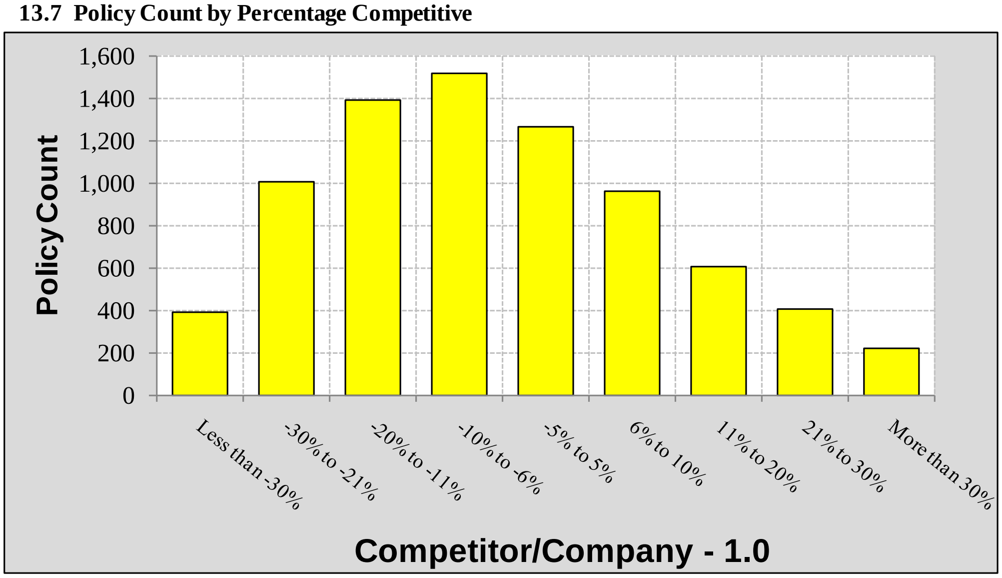
Companies are generally interested in two levels of competitiveness. First, companies want to understand how competitive their rates are on average (i.e., for all risks combined); this is sometimes referred to as a base rate advantage. Second, companies want to understand how competitive they are for individual risks or groups of risks (e.g., new homes or claims-free drivers).

Companies generally determine overall competitive position by comparing premiums for a set of sample risks,[46] for all quoted risks (for new business), or for all existing insureds (for renewal competitiveness). When doing so, companies typically focus on one or more of the following metrics:

- $\%\text{ Competitive Position} = \frac{\text{Competitor Premium}}{\text{Company Premium}}(\text{or the reciprocal}) - 1.0.$
- $\$\text{ Competitive Position} = \text{Competitor Premium} - \text{Company Premium} \ (\text{or the reverse})$
- $\%\text{Win} = \frac{\text{Number of Risks Meeting Criteria (e.g., Premium Lower than Competitor)}}{\text{Total Number of Risks}}$
- $\text{Rank} = \text{Rank of Company Premium when compared to the premium from several competitors}$

The following chart shows a distribution of policies for different ranges of the percentage competitive measure:

13.7 Policy Count by Percentage Competitive

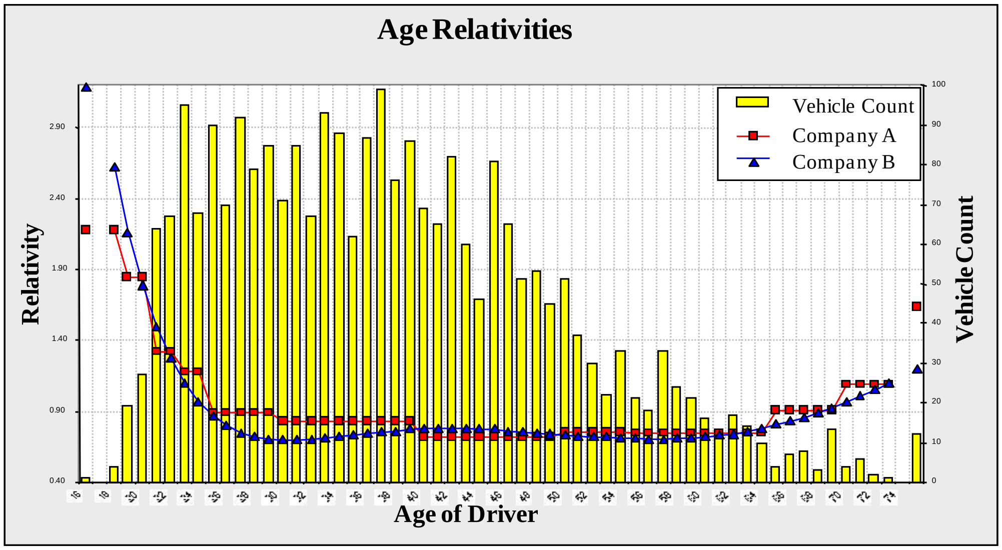


In this graph, the x-axis represents different ranges of the percent competitive position. If the two companies being compared charge exactly the same premium, then all policies will be in the range containing 0% (i.e., -5% to 5%). On the other hand, if the competitor has a very different premium structure, the bars will be dispersed across the different ranges. In the example, the overall average competitive position is -7% (i.e., on average, the competitor's premium is 7% lower than the company's premium), but the competitiveness ranges from a low of -60% to a high of over 100%. This variation in the competitive index highlights significant differences in the rating algorithms and rate relativities between the two companies. Similar charts can be produced for the other metrics.

[46] This is also referred to as a market basket of risks.

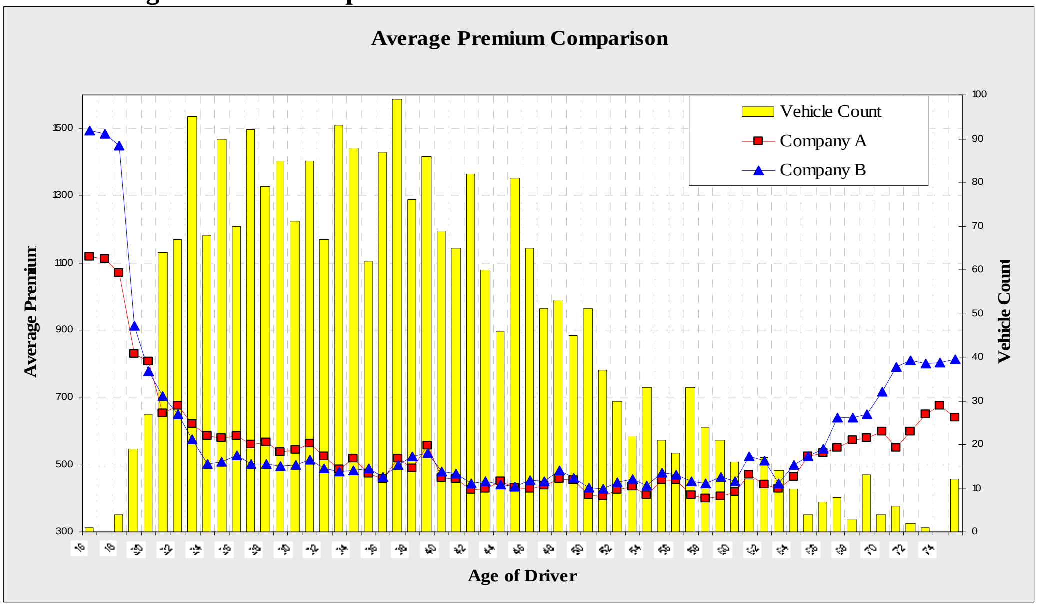
The competitiveness of different segments is often studied via rate relativity comparisons. For example, Chart 13.8 shows a typical comparison of age relativities for personal automobile coverage. In this graph, the x-axis shows the different levels of the variable being studied (i.e., ages), the bars represent the number of vehicles for each level of age (right y-axis), and the lines represent the rate relativities by company (left y-axis).

13.8 Relativity Comparison



This type of competitive analysis can be very effective when the rating algorithms are similar between companies. In recent years, rating algorithms have become much more complex, often including many more risk characteristics than previously. Consequently, individual rate relativity comparisons may be less meaningful. For example, the above comparison of age relativities may not be useful if one company also includes other age-related factors in its rating algorithm (e.g., retiree discounts, inexperienced operator surcharges) that the other company does not. Additionally, rating variables may be additive for one company and multiplicative for another company. Because of this, companies have begun to use total premium comparisons for groups of risks sharing the rating characteristic of interest. Chart 13.9 shows the average premium by age rather than the rate relativities by age.

13.9 Average Premium Comparisons



While this does not account entirely for carriers having different sets of rating variables, it does provide an indication of where competitive threats and opportunities may exist for the company's existing rating variables. Care must be taken when using this type of analysis, however, as a change in one variable's rate relativities can have an unintended impact on the average premium of a certain level of another variable. For example, if square footage is introduced as a rating variable in homeowners insurance, it may significantly change the average premium of certain territories or amount of insurance levels (as those characteristics tend to be highly correlated with square footage).

Close Ratios, Retention Ratios, Growth

Close ratio (also known as hit ratio, quote-to-close ratio, or conversion rate) is a measure of the rate at which prospective insureds accept a new business quote and is defined as follows:

$$\text{Close Ratio} = \frac{\text{Number of Accepted Quotes}}{\text{Total Number of Quotes}}.$$

Thus if the company issues 25,000 quotes in a particular month and generates 6,000 new policies from those quotes, then the close ratio is 24% (= 6,000 / 25,000). Care should be taken to understand the data used to calculate the ratio, especially when comparing to another carrier's ratio. For example, Company A may include in the denominator all quotes issued, and Company B may only include one quote per applicant. If this is the case, Company A will have a lower close ratio, all else being equal, if applicants routinely request more than one quote before making a decision (e.g., if an applicant gets several quotes with different limits).

Retention ratio (also known as persistency ratio) is a measure of the rate at which existing insureds renew their policies upon expiration and is defined as follows:

$$\text{Retention Ratio} = \frac{\text{Number of Policies Renewed}}{\text{Total Number of Potential Renewal Policies}}.$$

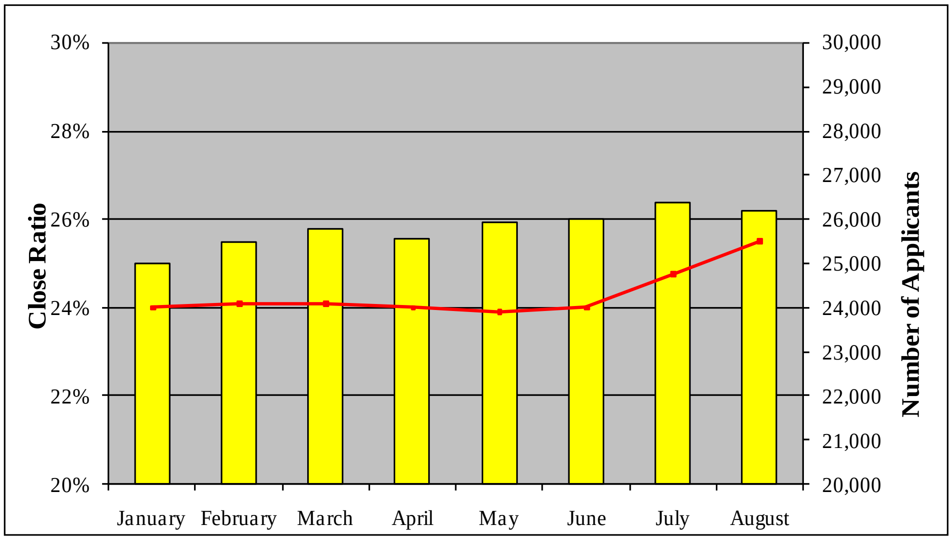
If 30,000 policies are up for renewal in a particular month and 24,000 of the insureds choose to renew, then the retention ratio is 80% (= 24,000 / 30,000). All else being equal, renewal customers tend to be less expensive to service and generate fewer losses on average than new business customers. Consequently, retention ratios and changes in the retention rate are monitored closely by marketing departments as companies generally want to retain as many profitable customers as possible.

Care should be taken to understand the data used to calculate the retention ratio. For example, if Company A excludes from the calculation all policies that were non-renewed by the company (i.e., the company canceled the policy as it no longer met the eligibility criteria), and Company B includes them, then Company A will have a better retention ratio than Company B, all else being equal.

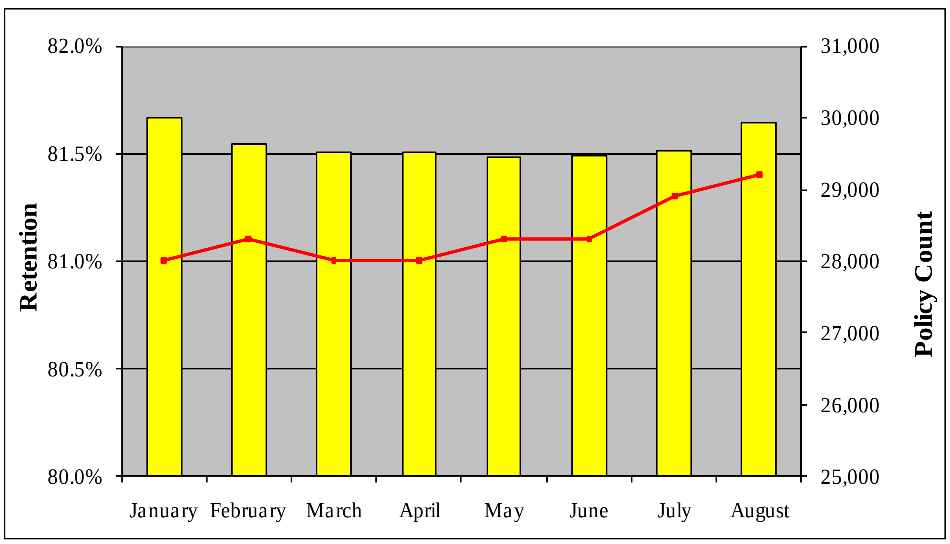
Analysts study both the absolute ratios and changes in the close and retention ratios. As price is a major determinant of customer buying decisions, companies frequently rely on close ratios and retention ratios as primary signals of the competitiveness of rates for new business and renewal customers, respectively. Changes in these ratios are often used to gauge changes in competitiveness. Companies also scrutinize close ratios and retention ratios when rate changes are implemented. Rate changes affect renewal business directly, and any change from the status quo can motivate existing customers to shop for insurance elsewhere. Rate changes also influence the company's competitive position, which is considered heavily by the price-sensitive new business prospects. If a company takes a rate decrease, the expectation is that the close and retention ratios will improve; similarly, a rate increase will generally lead to reductions in these ratios. (Note these changes may be neutralized if competitors are making similar changes.)

Charts 13.10 and 13.11 are typical charts comparing close ratios and retention by month (x-axis). The bars represent the number of applicants or renewals (right y-axis) for each month. The line represents the close or retention ratio (left y-axis) for each month. The increase in each ratio over the last couple months coincides with a rate decrease implemented in July.

13.10 Close Ratios by Month



13.11 Retention Ratios by Month

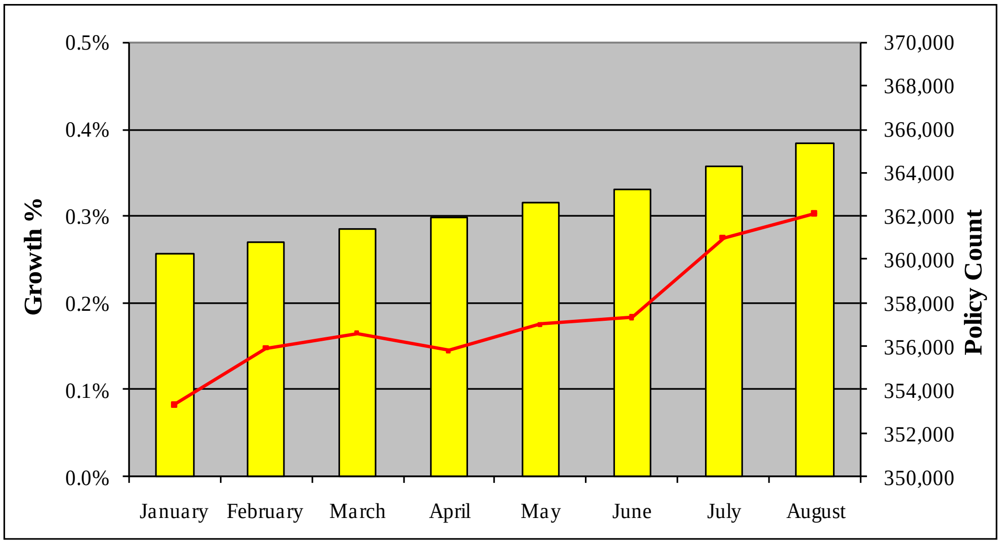


Growth is a function of attracting new business and retaining existing customers. More specifically, policy growth rate is defined as:

$$\%\text{ Policy Growth} = \frac{(\text{New Policies Written} - \text{Lost Policies})}{\text{Policies at Onset of Period}} = \frac{\text{Policies at End of Period}}{\text{Policies at Onset of Period}} - 1.0,$$

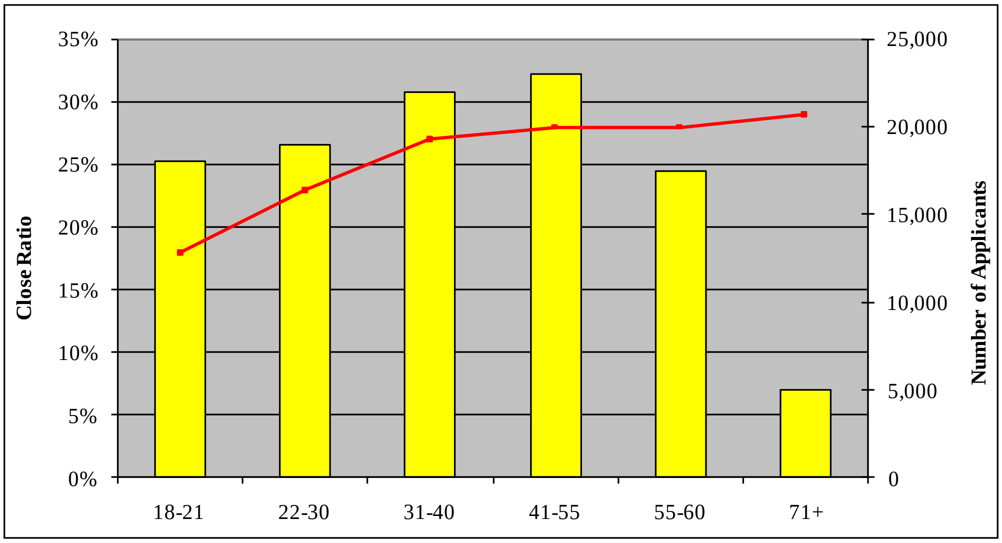
where a "lost policy" can either be a cancelled or non-renewed policy. Assume there were 360,000 policies at the beginning of the month. If 9,600 new policies were added and 6,000 policies were lost during the month, then the monthly policy growth is 1.0% (= [9,600 - 6,000] / 360,000). As with retention and close ratios, growth percentages are tracked over time. Low or negative growth can indicate uncompetitive rates and vice versa. Of course, changes in growth can also be significantly impacted by items other than price. For example, if a company tightens or loosens the underwriting standards, growth can be affected. In general, companies want to be aware of rapid changes in the volume of insureds and monitor the effect on profitability. Chart 13.12 shows monthly policy growth.

13.12 Policy Growth by Month



The close, retention, and growth ratios described above were calculated at the aggregate level. Companies may also track these for specific groups of insureds. If any of the ratios look significantly worse for a particular segment despite having similar competitiveness as other segments, then it may be an indication that the particular segment is more price sensitive, that the competitive rate comparisons are not valid, or that something other than price is driving the purchasing decision. Chart 13.13 shows an example of close ratios by age of named insured. The bars represent the number of applicants (right y-axis) and the line represents the close ratio (left y-axis) by age of applicant (x-axis).

13.13 Close Rates by Age of Named Insured



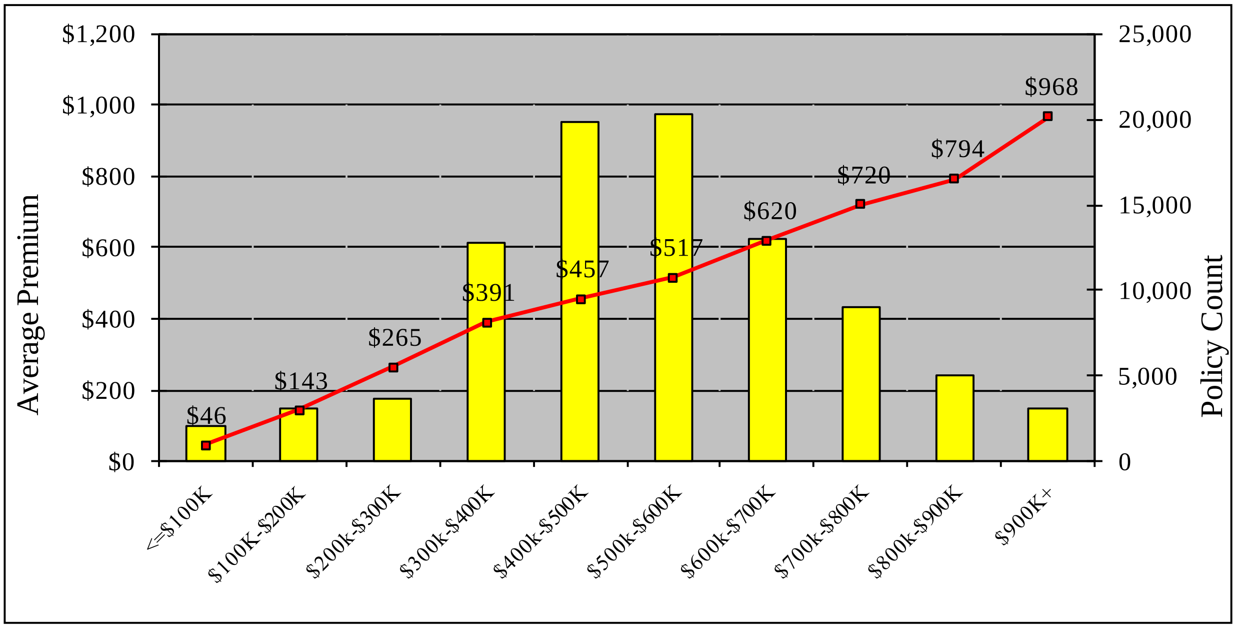
It is interesting to note that the close rate is the lowest for the younger insureds. Even if the competitive position is similar across all age groups, this result is not surprising as younger insureds tend to be more price-sensitive. Similar information can be examined for retention and growth.

Distributional Analysis

Companies may also examine distributions of new and renewal business by customer segment. A distributional analysis normally includes both the distribution by segment at a given point of time and changes in distributions over time.

For example, a company may examine the distribution of policies by various amounts of insurance (AOI) categories for homeowners. For additional information, the average premium for each category is included. Chart 13.14 shows the number of policies (right y-axis) and average premium (left y-axis) for each AOI category (x-axis).

13.14 Policies and Average Premium by AOI Range



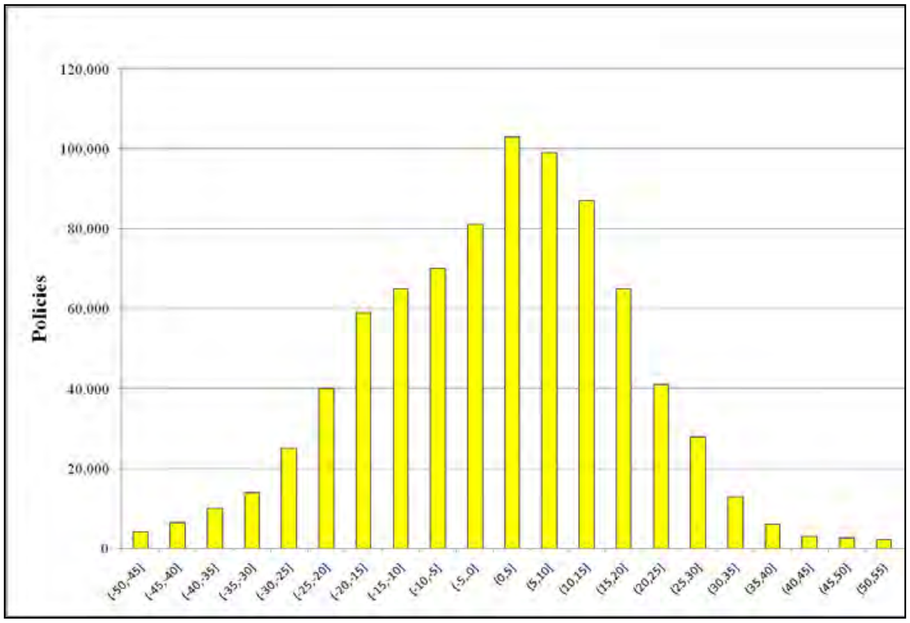
This distributional information should be considered in the context of the general population of insureds and the target distribution for the company. For example, the distributional analysis may uncover that while 15% of homes in a market are valued under $200,000, only 5% of the homes in the company's portfolio have an amount of insurance in that range. Assuming the company wants to insure those homes, this may be an indication that the rates for homes in this range are uncompetitive. It could also indicate other issues such as poor marketing or inadequate agent placement. A comparison of distributions over time can reveal whether this low penetration has been consistent or if it is a recent development. If it is a recent development, it could also indicate that a major competitor recently began targeting homes valued less than $200,000 (via marketing strategy, price strategy, etc).

Policyholder Dislocation Analysis

Existing customers are directly impacted when rates are changed; consequently, the amount of any rate change can be a major influence on whether or not an existing insured decides to renew the policy. The purpose of dislocation analysis is to quantify the number of existing customers that will receive specific amounts of rate change. The company often uses this information to extrapolate how the rate change may affect retention. In the absence of sophisticated retention modeling techniques (discussed briefly in the next section), companies typically have a threshold defining the magnitude and dispersion of rate changes that the company believes will produce an unacceptable effect on retention (in total or by customer segment). If the dislocation analysis highlights the effects are outside the tolerance level, the company may revise the proposed rate change. In addition, knowledge of the expected dislocation can be shared with the sales channel and customer support units (e.g., call centers) in advance of the implementation to help them prepare for the potential customer response (e.g., a customer calling an agent about a large premium increase).

When a simple base rate change is implemented, the amount of dislocation is nearly uniform across all insureds. If rate relativities are also changed, the amount of dislocation can vary significantly for different insureds or classes of insureds. Typically, companies look at the distribution of rate changes across the entire book of business, summarized by key segments, and by each level of rating variables being specifically adjusted. Chart 13.15 shows the distribution of policies across various rate change ranges.

13.15 Rate Change Distribution



Assimilating the Information

Once the traditional actuarial indications and marketing considerations are known, the decision-maker needs to weigh all information and select the rates that best meet the goals of the company. Typically, this is done judgmentally.

For example, assume the following about a particular class of business:

- Current average premium = $1,000
- Indicated average premium = $1,200 (or 20% increase)
- Competitor's average premium = $1,000
- Close ratio, retention ratio, and growth are all significantly below target

The company may conclude that implementation of a 20% increase will cause significant loss of renewal customers and prohibit new business growth. In this situation, the company should consider the ramifications of implementing the change versus not implementing the change. If the company decides the full increase should not be implemented, it can consider other non-pricing solutions to improve profitability (e.g., revise underwriting guidelines or marketing strategies). Along the same lines, in markets where rates are promulgated by regulation or rate changes are difficult to obtain, companies often perform ratemaking analysis but rely on the information to improve profitability through these non-pricing solutions.

Systematic Techniques for Incorporating Marketing Considerations

Some companies use techniques to more systematically incorporate both marketing information and actuarial indications when proposing rates. A couple of these techniques will be discussed here briefly, but an in-depth review is outside the scope of this text.

Lifetime Value Analysis

Standard actuarial ratemaking techniques develop the cost-based indicated rate required to achieve the targeted underwriting profit over a short period of time (i.e., one year) assuming all insureds will renew. Lifetime value analysis tries to improve upon this by examining the profitability of an insured over a longer period of time taking into account that not all insureds will renew. To do this, assumptions are made regarding the propensity of the insured to renew and the expected profitability of the insured over the time period being projected.

Tables 13.16 and 13.17 show an example of a personal automobile lifetime value calculation for analyzing the longer term profitability of a 22-year-old and a 70-year-old. The first row of each table represents the first policy year for the 22-year-old and 70-year-old, respectively. The subsequent rows of each table show subsequent policy years, as each individual ages. The premium, losses, expense, and persistency (i.e., the probability the risk will not cancel) are given for each year. Premium varies by year reflecting any expected rate and relativity changes; losses vary by year reflecting overall loss trends and changes in expected costs as the insured ages; and expenses vary reflecting different costs for new and renewal business. Columns 2 through 4 are used to calculate the profit in Column 5. Column 6 shows the probability that the risk will renew that year, and Column 7 converts the renewal probability of each year into a cumulative persistency. The profit in Column 5 is reduced to reflect the cumulative persistency in Column 7, and the result is shown in Column 8. This value is essentially profit adjusted to reflect that not all customers will renew. Column 9 is the present value of the adjusted profit from Column 8, reflecting the time value of money. Column 10 is the present value of the premium, taking cumulative persistency into account as well. Column 11 is the ratio of Column 9 to Column 10; profit as a percentage of premium is a commonly used profit measure.

Based on the percentage profit over a one-year time horizon (i.e., the first row in each table), a 70-year-old is more profitable to insure than a 22-year-old. However, over a four-year time horizon, the 22-year-old (who is age 25 at the end of the time period) is more profitable than the 70-year-old (who is age 73 by the end of the time period).

13.16 Four-Year Time Horizon for 22-Year-Old

Year	(1) Age	(2) Prem	(3) Losses	(4) Expense	(5) Profit	(6) Renewal Prob	(7) Cumulative Persistency	(8) Adj Profit	(9) PV of Adj Profit	(10) PV of Premium	(11) Profit %
1	22	$ 810	$ 800	$ 35	$ (25)	100.0%	100.0%	$ (25.00)	$ (25.00)	$ 810.00	-3.1%
2	23	$ 800	$ 750	$ 15	$ 35	75.0%	75.0%	$ 26.25	$ 25.00	$ 571.43	4.4%
3	24	$ 790	$ 700	$ 15	$ 75	75.0%	56.3%	$ 42.23	$ 38.30	$ 403.42	9.5%
4	25	$ 780	$ 650	$ 15	$ 115	80.0%	45.0%	$ 51.75	$ 44.70	$ 303.21	14.7%
Total		$3,180	$2,900	$ 80	$ 200			$ 95.23	$ 83.01	$2,088.06	4.0%

13.17 Four-Year Time Horizon for 70-Year-Old

Year	(1) Age	(2) Prem	(3) Losses	(4) Expense	(5) Profit	(6) Renewal Prob	(7) Cumulative Persistency	(8) Adj Profit	(9) PV of Adj Profit	(10) PV of Premium	(11) Profit %
1	70	$ 600	$ 550	$ 35	$ 15	100%	100.0%	$ 15.00	$ 15.00	$ 600.00	2.5%
2	71	$ 600	$ 578	$ 15	$ 7	95%	95.0%	$ 6.65	$ 6.33	$ 542.86	1.2%
3	72	$ 600	$ 606	$ 15	$ (21)	96%	91.2%	$ (19.15)	$ (17.37)	$ 496.33	-3.5%
4	73	$ 600	$ 640	$ 15	$ (55)	97%	88.5%	$ (48.68)	$ (42.05)	$ 458.70	-9.2%
Total		$2,400	$2,374	$ 80	$ (54)			$ (46.18)	$ (38.09)	$2,097.88	-1.8%

(5)= (2) - (3) - (4)
(7)= (6) x (Prior7)
(8)= (5) x (7)
(9)= (8) discounted by 5% per annum
(10)= (2) x (7) discounted by 5% per annum
(11)= (9) / (10)

Improvements to this type of analysis may include refining the assumptions, increasing the time horizon, and incorporating results from other products the customer may also purchase. More information on this type of analysis can be found in "Personal Automobile Premiums: An Asset Share Pricing Approach for Property/Casualty Insurance" (Feldblum 1996).

Optimized Pricing

Originally, multivariate statistical modeling techniques were used primarily to determine better estimates of loss costs for insureds with different characteristics. More recently, these same techniques are being applied to develop renewal and conversion models (i.e., customer demand models). These models are used to estimate the probability that an applicant will accept a quote (i.e., conversion model) or that an existing customer will accept the renewal offer (i.e., retention model).

The historical data used to develop these models includes a series of observations and a corresponding response for each observation. For example, a conversion model dataset contains a series of new business quotes and whether each quote was accepted or rejected. A retention model dataset contains a series of renewal offers and whether each offer was accepted or rejected. Each dataset should also include relevant information about each observation, including risk characteristics, amount of premium quoted, rate change information (for retention models), and an indicator of the competitiveness of the premium. The resulting models can help predict the change in close rate or retention rate in response to a proposed rate change, given a set of observations and associated characteristics.

13.18 Retention Model Output

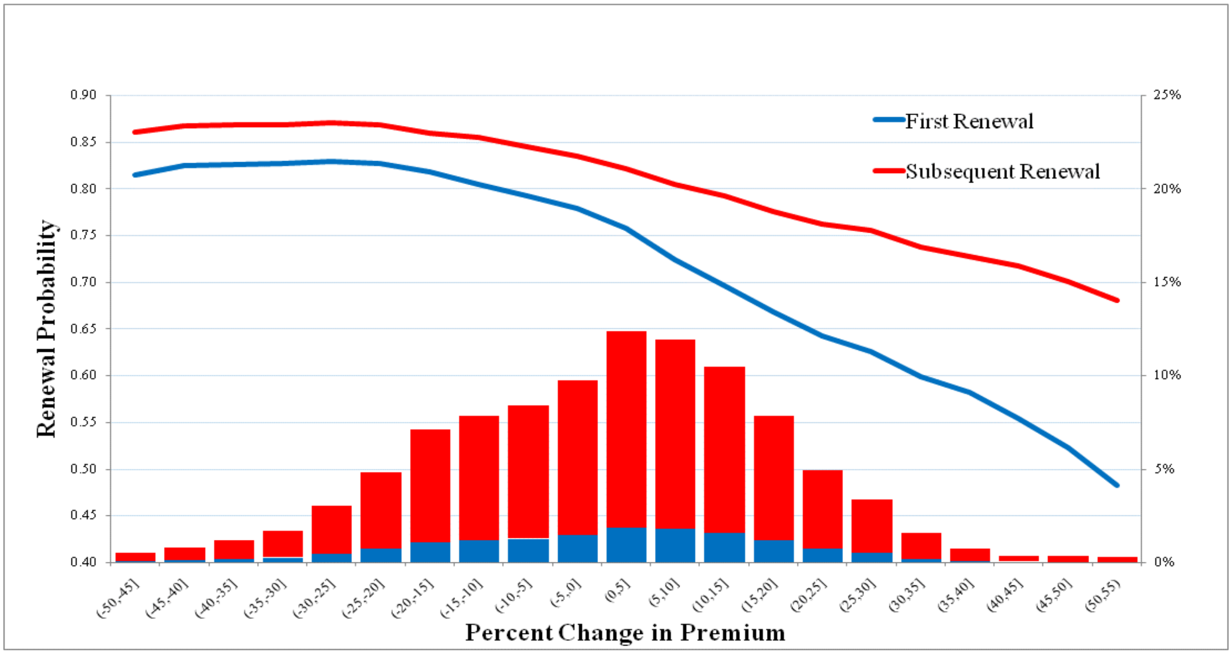


Chart 13.18 shows example output from a retention model. The bars represent the percentage of policies (right y-axis) getting different percentage change in premium (x-axis). The lines illustrate the insured's propensity to renew (left y-axis) depending on whether it is the first or subsequent renewal for the insured. As the premium changes increase, the blue line drops more steeply than the red line, highlighting that the longer the insured is with the carrier, the less sensitive he or she is to premium increases.

A loss cost model and a customer demand model can be used together to estimate expected premium volume, losses, and total profits for a given rate proposal. For renewal business, the loss cost and retention models project the expected profitability and probability of renewal for each existing risk at a given price. Given these models, a company can test several rate change scenarios on the in-force distribution to determine the expected volume, premium, losses, and profit of each scenario. The objective is to identify the rate change that best achieves the company's profitability and volume goals on the renewal portfolio. This same process can also test multiple rate scenarios on new business by applying the results of loss cost models and conversion models on a portfolio of quotes.

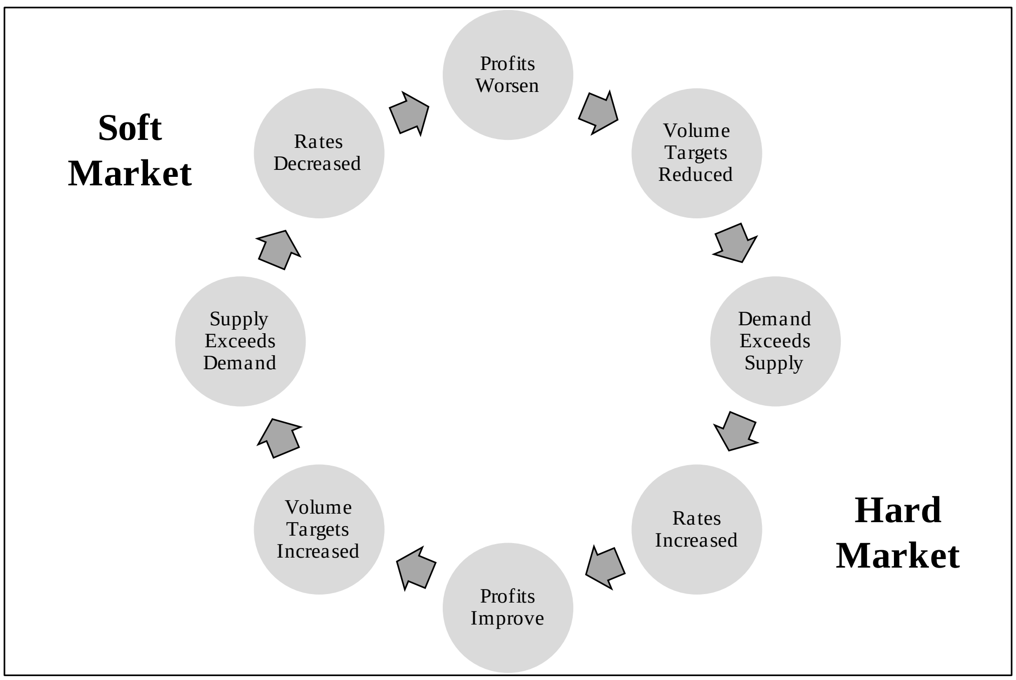
Scenario testing rate changes is a precursor to full price optimization. Optimization algorithms incorporate loss cost models, demand models, and other assumptions as inputs, and generate hundreds of thousands of scenarios to determine the premium for each individual risk that optimizes overall profit while achieving a company's overall volume goals (or optimize volume while achieving a company's overall profitability goals). The algorithms can be as simple or complex as desired. Complex algorithms may take into account several per policy constraints (e.g., minimum premium or profit per policy), include models on the propensity to cross-sell, and consider time horizons longer than one year. Regardless of the complexity of the optimization routine, the ratemaking actuary may still have the challenge of determining how to translate individually optimized premium into a manual rate structure, depending on the product being priced. (This is outside the scope of this text.) In addition, the considerations covered earlier in this chapter (regulatory and operational) still apply.

In summary, actuaries have always considered both expected loss costs and customer demand when setting rates, although the customer demand aspect was often incorporated judgmentally. Optimized pricing more systematically combines knowledge of loss costs and customer demand to develop rates that meet the particular volume and profitability objectives of the company, and represents an improvement over traditional techniques.

Underwriting Cycles

When determining which rates to implement, it is important to understand that the insurance industry historically has cyclical results. In other words, the overall profitability of the industry tends to oscillate systematically. The industry uses the terms “hard market” and “soft market” to identify the peaks and valleys of this cycle. The hard market refers to periods of higher price levels and increased profitability. Normally, companies respond to this profitability by trying to expand their market share. To do this, some companies become more aggressive in their pricing (often deviating from actuarial indications), which puts pressure on other companies to respond by reducing prices. This generally leads to a soft market, during which profits are lower. In response to the low profits generated during a soft market, companies again begin to focus more on the actuarial indications and take appropriate rate increases. Thus, competitive pressures ease and the cycle begins again. The cycle is demonstrated pictorially in Figure 13.19.

13.19 Underwriting Cycle



When making pricing decisions, it is important that the actuary understands the existence of underwriting cycles and considers the current cycle stage of the industry. By understanding this, the company can better respond to changes in the market conditions.

For more detailed information on underwriting cycles, refer to “The Impact of the Insurance Economic Cycle on Insurance Pricing” (Boor 2004).

SUMMARY

Insurance companies invest considerable resources to perform ratemaking analysis, but do not always implement the actuarially indicated rates. Two reasons that a company may implement something other than the indicated rates are regulatory constraints and operational constraints. In addition, marketing considerations such as competitive position, customer demand, and underwriting cycle may lead the company to deviate from indicated rates. Traditional pricing strategy incorporates these market considerations judgmentally, but advanced techniques such as lifetime customer value and optimized pricing can accomplish this more systematically.

KEY CONCEPTS IN CHAPTER 13

1. Regulatory constraints
2. Operational constraints
    a. Types of operational constraints
    b. Cost-benefit analysis
3. Market considerations
    a. Traditional analysis
        i. Competitive comparisons
        ii. Close ratios
        iii. Retention ratios
        iv. Distributional analysis
        v. Policyholder dislocation analysis
    b. Systematic analysis
        i. Lifetime customer value
        ii. Optimized pricing
    c. Underwriting cycles

CHAPTER 14: IMPLEMENTATION

As discussed throughout the paper, the fundamental insurance equation is:

Premium= Losses + LAE + UW Expenses + UW Profit.

Prior chapters provide techniques to project the individual components of the equation in order to determine whether or not the equation will be in balance for a given set of rates. This chapter discusses potential actions a company can take if its current rates do not produce an average premium that is equivalent to the sum of the expected costs and target underwriting profit. In particular, this chapter discusses:

- Non-pricing solutions to an imbalanced fundamental insurance equation
- Rate change solutions, including detailed discussion of how to calculate final rates for existing products and products being introduced
- Communicating the expected effect of rate changes to key stakeholders (e.g., regulators and company management) and monitoring results after implementation.

EXAMPLE IMBALANCE

This chapter uses the notation introduced in the Foreword to this text, and considers the same pricing example and assumptions presented in prior chapters (referred to as the "simple example"):

- The average expected loss and LAE ($\bar{L} + \overline{E_L}$) for each exposure is $180.
- Each time the company writes an exposure, the company incurs $20 in fixed expenses ($\overline{E_F}$).
- 15% of each dollar of premium collected covers expenses (V) that vary with the amount of premium, such as premium taxes.
- Company management has determined that the target profit provision (Q_T) is 5% of premium.

Based on the expected losses, expenses, and target underwriting profit in the future policy period, the indicated average premium per exposure is $250 (= ($180 + $20) / (1.0 – 15% – 5%)).

If the projected average premium assuming the company's current rates is $235, then the fundamental insurance equation is not in balance. The company can bring the equation into balance by reducing its costs (non-pricing solutions) or increasing its rates or both.

NON-PRICING SOLUTIONS

A company may try to achieve balance through expense reductions (i.e., reduction in UW or LAE expenses). For example, the company may try to reduce the marketing budget or reduce the staffing levels. In the simple example, the equation will be brought into balance if the fixed expenses per exposure are reduced from $20 to $8, or the variable expenses are reduced from 15% to 10%. If the company actuary projects a reduction in expenses, the overall rate level indication should be updated accordingly.

A company can also achieve balance by reducing the average expected loss. One way to do this is to change the make-up of the portfolio of insureds. For example, a company may tighten the underwriting criteria or non-renew policies that have grossly inadequate premium relative to expected costs. It is important to note that when the portfolio changes, both the expected losses and expected premium may change; however, if the loss reduction is greater than the premium reduction, the underwriting action could move the fundamental equation to the balanced position. If a company does this, then the actuary should adjust the premium and loss projections and recalculate the overall rate level indication.

Another way to reduce average expected loss is to reduce the coverage provided by the policy. A reduction or expansion of coverage is referred to as a coverage level change. For example, a homeowners insurer may adjust the policy to exclude coverage for mold losses. If this action eliminates previously covered losses and rates are not decreased accordingly, then this coverage level change is equivalent to a rate level increase. In the simple example, the company needs to reduce the average expected loss and LAE from $180 to $168 to bring the fundamental insurance equation into equilibrium. If a company accomplishes such a change, then the actuary should adjust the projected losses and LAE and recalculate the overall rate level indication.

These two methods above are not the only approaches to reduce average expected loss. Companies may also institute better loss control procedures. For example, a workers compensation carrier may be able to reduce average severity by applying proactive medical management procedures and return-to-work programs for disability claims that are likely to escalate.

PRICING SOLUTIONS

The typical company response to an unbalanced fundamental equation is to adjust the rates or expect an underwriting profit below the target underwriting profit until adjustments can be made. In the simple example, the overall rate level analysis indicates a need to increase the average rate from $235 to $250, but the company may choose not to do this. Chapter 13 addressed reasons a company may implement rates different from those indicated. If the company decides that $235 is the most that can be charged in the short run, then the company is, in effect, forced to accept the resulting target underwriting profit provision of -0.1% (= ($235 - $180 - $20 – (15% x $235)) / $235) until rates can be increased.

Since achieving the target underwriting profit is important, most companies choose to change the current rates (i.e., implement a rate change) to achieve or at least get closer to the desired equilibrium. The next section covers the process that the actuary may use to revise the rates of an existing product to the desired level. Calculating rates for a new product will be covered later in the chapter.

CALCULATING NEW RATES FOR AN EXISTING PRODUCT

In order to calculate a final set of rates for an existing product, the company must:

- Select an overall average premium target for the future policy period
- Finalize the structure of the rating algorithm
- Select the final rate differentials for each of the rating variables
- Calculate proposed fixed expense fees and other dollar additives, if applicable
- Derive the base rate necessary to achieve the overall average premium target

Chapter 8 discusses the calculation of the overall rate level indication, and Chapters 9 through 11 discuss calculation of the proposed rate differentials. Chapter 13 discusses conditions that may cause selections of overall rate levels or rate differentials to deviate from indicated.

The next sections of this chapter use a simple example to illustrate the calculation of the fixed expense fees and the derivation of the base rate.

Example Rating Algorithm

As discussed in Chapter 2, the rating algorithm describes in detail how to combine the various rate components (e.g., base rates, rate differentials, expense fees, and other additive premium) to calculate the overall premium charged for any risk. Rating algorithms vary considerably by company and by product, and the determination of the most appropriate rating algorithm[47] is outside the scope of this text. When using any of the formulae described in this chapter, consider the specific rating algorithm of the product being priced, and modify as necessary.

The portion of the total premium that varies by risk characteristics (i.e., is a function of the base rate and rate differentials) is often referred to as **variable premium**. The portion of the premium derived from expense fees and other dollar additives is often referred to as **flat or additive premium**. These terms will be used throughout the remainder of the chapter.

For the purpose of explaining the expense fee and base rate derivation formulae, assume a simple rating algorithm that includes a base rate (B), two multiplicative rating variables ($R1$ and $R2$), two discounts ($D1$ and $D2$) that are subtracted from one and applied multiplicatively in the rating algorithm, and an additive per exposure expense fee (A). As before, P and X are used to denote premium and exposures, respectively. Using a subscript of P to refer to proposed and the subscripts of i, j, k, m to refer to different levels for the different rating variables/discounts, the proposed premium for a given risk can be defined as follows:[48]

$$P_{\mathrm{P},ijkm} = [[B_{\mathrm{P}} \text{ x } R1_{\mathrm{P},i} \times R2_{\mathrm{P},j} \times (1.0 - D1_{\mathrm{P},k} - D2_{\mathrm{P},m})] + A_{\mathrm{P}}] \times X_{ijkm}.$$

Example Rating Variable Differentials

The rating algorithm in the example contains two multiplicative rating variables ($R1$ and $R2$) and two discounts ($D1$ and $D2$). Assume the company relied on the following information to select proposed rate differentials for each rating variable:

[47] For example, the extent to which the formula should be multiplicative or additive.
[48] For some lines of business (e.g., homeowners insurance), the X_{ijkm} can be 1.0.

14.1 Differentials and Discounts

R1	Current Differential	Indicated Differential	Competitor Differential	Proposed Differential
1	0.8000	0.9000	0.9200	0.9000
2	1.0000	1.0000	1.0000	1.0000
3	1.2000	1.2500	1.2500	1.2500

R2	Current Differential	Indicated Differential	Competitor Differential	Proposed Differential
A	1.0000	1.0000	1.0000	1.0000
B	1.0500	0.9000	0.9500	0.9500
C	1.2000	1.3000	1.3500	1.3000

D1	Current Discount	Indicated Discount	Competitor Discount	Proposed Discount
Y	5.0%	4.0%	5.0%	5.0%
N	0.0%	0.0%	0.0%	0.0%

D2	Current Discount	Indicated Discount	Competitor Discount	Proposed Discount
Y	10.0%	2.5%	7.5%	5.0%
N	0.0%	0.0%	0.0%	0.0%

Calculation of Fixed Expense Fees and Other Additive Premium

If the rating algorithm incorporates fixed expenses through an additive per exposure expense fee, that fee is typically based on the average fixed expense per exposure. In addition, the fee must be adjusted to account for variable underwriting expenses and underwriting profit in the same way that losses and LAE per exposure are adjusted for these items in the rate level indication formulae. In other words, the company incurs variable expenses and expects target profit on all premium, including that which comes from fixed expense fees.

The adjustment to the expense fee to account for variable expense and profit is accomplished by dividing the average fixed underwriting expense by the variable permissible loss ratio:

$$A_{\mathrm{P}} = \frac{\overline{E_{\mathrm{F}}}}{(1.0 - V - Q_{\mathrm{T}})}.$$

The following shows the calculation of the proposed expense fee in the simple example:

14.2 Calculation of Fee

(1)	Average Fixed Expense per Exposure	$20.00
(2)	Variable Expense %	15.0%
(3)	Target Profit %	5.0%
(4)	Variable Permissible Loss Ratio	80.0%
(5)	Proposed Expense Fee	$25.00

(4)= 1.0 - (2) - (3)
(5)= (1) / (4)

In this example, the proposed $25 additive fee includes $20 to cover the fixed expenses and $5 to cover the variable expense (e.g., premium tax) and profit associated with the $20.

Some companies use a fixed per policy expense fee rather than a fixed per exposure expense fee in the rating algorithm. It is important that base rate derivation formulae discussed in the next section combine average variable premium and average flat premium on a consistent basis (i.e., per policy or per exposure). A per policy expense fee can be converted to a per exposure expense fee by dividing by the average number of exposures per policy.

Also, it is possible that the variable expense provision (*V*) used to adjust the fixed expense fee differs from that used in calculating the overall rate level indication. This can occur when companies elect not to apply certain aspects of the variable expenses to the flat fee. For example, some companies do not make the flat fee subject to agent commissions.

If the premium-based expense projection method is used (as discussed in Chapter 7), a fixed expense ratio is calculated rather than a fixed expense dollar amount. The ratio can be converted to a dollar amount by multiplying it by the projected average premium per exposure, as shown in the following table.

14.3 Calculation of Fee (Fixed Expense Ratio)

(1) Fixed Expense Ratio		8.0%
(2) Projected Average Premium per Exposure	$	250.00
(3) Average Fixed Expense per Exposure	$	20.00
(4) Variable Expense %		15.0%
(5) Target Profit %		5.0%
(6) Variable Permissible Loss Ratio		80.0%
(7) Proposed Expense Fee	$	25.00

(3) = (1) x (2)
(6) =1.0 - (4) - (5)
(7) = (3) / (6)

In addition to fixed expense fees, some rating algorithms have other additive premium components. For example, in the homeowners line of business, many endorsements that add or extend coverage are priced separately and added to the variable premium of the standard policy. The same adjustment as described above for fixed expense fees applies to other additive premium as well.

Derivation of Base Rate: No Rate Differential Changes

Once the actuary selects the proposed average premium (or proposed change in average premium), proposed rate differentials, and proposed fixed expense fees and other additive premium, the remaining task is to determine the proposed base rate. Essentially, the base rate is derived such that proposed average premium (or change in average premium) is expected to be achieved. Regardless of whether the pure premium method is used to calculate a target average premium, or the loss ratio method is used to calculate a target change in average premium, the goal is the same: to derive a base rate that achieves the target.

First consider the simple scenario when there is only variable premium and rate differentials are not changing. In this case, the proposed base rate is equal to the current base rate times the ratio of the proposed average premium to current average premium:

$$B_P = B_C \times \frac{\overline{P_P}}{\overline{P_C}}.$$

If there are flat premium components (and rate differentials are still not changing), the proposed base rate is equal to the current base rate times the ratio of the proposed average variable premium to the current average variable premium:

$$B_P = B_C \times \frac{(\overline{P_P} - A_P)}{(\overline{P_C} - A_C)}.$$

To understand this base rate formula when there is a flat premium component, consider the example where a 5.0% overall average premium change is targeted. The 5.0% change can be achieved by increasing the base rate 5.0% and increasing the flat premium 5.0%. Alternatively, if it is undesirable to change flat premium (i.e., keep A_P the same as A_C), the base rate change needs to be increased such that the total average premium change will be achieved. This is because the base rate change only affects variable premium. If flat premium is assumed to be 10% of the total average premium (and the amount of flat premium is not changing with this rate review), the base rate has to increase by 5.56% in order to achieve the 5.0% overall change (i.e., 5.0% = 90% (5.56%) + 10% (0.0%)).

Derivation of Base Rate: Rate Differential Changes

The next section describes three base rate derivation approaches to use if rate differentials are changing:

- Extension of exposures
- Approximated average rate differential
- Approximated change in average rate differential

The extension of exposures method is the most direct and most accurate, but requires detailed data. The approximated methods are used when application of extension of exposures is not practical for the product being priced.

Extension of Exposures Method

Chapter 5 discussed the extension of exposures technique as a method to rerate individual policies, or unique combinations of rating variables, according to a current set of rates in order to calculate earned premium at current rate level. The same general technique is applied to derive a proposed base rate. Policies are rerated in consideration of the proposed rate differentials, proposed flat premium, and a placeholder value for the unknown proposed base rate (referred to as a seed base rate or B_S[49]). If the resulting proposed average premium matches the target average premium, then the placeholder base rate is the correct proposed base rate. If not, the placeholder base rate requires adjustment, as described below.

[49] The seed base rate is an initial approximation of the proposed base rate. It is merely a means to an end. The proposed base rate will be derived from the seed base rate using algebra, as will be discussed. In practice, the seed base rate is often selected as the current base rate or the current base rate adjusted by the selected overall change in average premium.

In the example, the extension of exposures technique is used to rerate individual policies[50] using the proposed rate differentials ($R1_P$, $R2_P$, $D1_P$, $D2_P$), a proposed fixed expense fee per exposure (A_P), and some seed value for the proposed base rate (B_S). Using the notation presented earlier, the proposed premium per policy, assuming the seed base rate, is:

$$P_{S,ijkm} = [[B_S \text{ x } R1_{P,i} \times R2_{P,j} \times (1.0 - D1_{P,k} - D2_{P,m})] + A_p] \times X_{ijkm}.$$

Once each set of policies is rerated, the premium is aggregated across some distribution (e.g., the latest in-force distribution) and divided by the total exposures. The resulting average proposed premium assuming the seed base rate is:

$$\overline{P_S} = \frac{\sum_i \sum_j \sum_k \sum_m [[[B_S \text{ x } R1_{P,i} \times R2_{P,j} \times (1.0 - D1_{P,k} - D2_{P,m})] + A_p] \times X_{ijkm}]}{X},$$

which can be simplified as:

$$\overline{P_S} = B_S \times \frac{\sum_i \sum_j \sum_k \sum_m \left[[R1_{P,i} \times R2_{P,j} \times \left(1.0 - D1_{P,k} - D2_{P,m}\right)] \times X_{ijkm} \right]}{X} + A_p.$$

Table 14.4 shows the extension of exposures method applied to data from the example. Assuming a seed base rate of $215, the resulting proposed average premium is $246.83.

[50] For lines of business that are priced by coverage and/or by individual exposure, the extension of exposures and base rate derivation is calculated at that same level. For example, in personal automobile insurance, the base rate applies to the individual car at the coverage level.

14.4 Extention of Exposures (Assuming Seed Base Rate)

(1)	(2)	(3)	(4)	(5)	(6)	
Exposures	$R1$	$R2$	$D1$	$D2$	Proposed Premium (assuming Seed Base Rate = $215)	
10,000	1	A	Y	Y	$	1,991,500.00
7,500	2	A	Y	Y	$	1,638,750.00
3,000	3	A	Y	Y	$	800,625.00
9,000	1	B	Y	Y	$	1,713,982.50
20,000	2	B	Y	Y	$	4,176,500.00
5,000	3	B	Y	Y	$	1,273,960.00
1,875	1	C	Y	Y	$	471,365.63
5,000	2	C	Y	Y	$	1,382,750.00
2,000	3	C	Y	Y	$	678,875.00
3,500	1	A	N	Y	$	730,887.50
7,500	2	A	N	Y	$	1,719,375.00
3,500	3	A	N	Y	$	981,093.75
15,000	1	B	N	Y	$	2,994,667.50
36,000	2	B	N	Y	$	7,885,350.00
9,000	3	B	N	Y	$	2,407,873.50
3,750	1	C	N	Y	$	989,896.88
10,000	2	C	N	Y	$	2,905,250.00
2,000	3	C	N	Y	$	713,834.00
3,500	1	A	Y	N	$	730,887.50
7,500	2	A	Y	N	$	1,719,375.00
3,500	3	A	Y	N	$	981,093.75
15,000	1	B	Y	N	$	2,994,667.50
36,000	2	B	Y	N	$	7,885,350.00
9,000	3	B	Y	N	$	2,407,873.50
3,750	1	C	Y	N	$	989,896.88
10,000	2	C	Y	N	$	2,905,250.00
5,000	3	C	Y	N	$	1,784,585.00
48,000	1	A	N	N	$	10,488,000.00
112,500	2	A	N	N	$	27,000,000.00
25,000	3	A	N	N	$	7,343,750.00
11,000	1	B	N	N	$	2,297,075.00
250,000	2	B	N	N	$	57,312,500.00
65,000	3	B	N	N	$	18,220,312.50
28,125	1	C	N	N	$	7,777,968.75
68,000	2	C	N	N	$	20,706,000.00
15,000	3	C	N	N	$	5,615,625.00
869,500					$	214,616,746.63
(7) Avg Prop Prem (Base Seed = $215)					$	246.83

(6)= Calculated via extension of exposures with B_S =$215
(7)= (Tot6) / (Tot1)

The proposed average premium assuming a seed base rate is lower than the target average premium of \$250 so the seed base rate needs to be increased. The actuary can derive the proposed base rate via trial and error (i.e., testing various base rates until the target average premium is achieved). Alternatively, the actuary can calculate the amount the seed base rate needs to be adjusted via formula.

Recall that the formula for the proposed average premium assuming a seed base rate is:

$$\overline{P_S} = B_S \times \frac{\sum_i \sum_j \sum_k \sum_m \left[[R1_{P,i} \times R2_{P,j} \times (1.0 - D1_{P,k} - D2_{P,m})] \times X_{ijkm} \right]}{X} + A_p ,$$

and the formula for the proposed average premium assuming the proposed base rate is:

$$\overline{P_P} = B_P \times \frac{\sum_i \sum_j \sum_k \sum_m \left[[R1_{P,i} \times R2_{P,j} \times (1.0 - D1_{P,k} - D2_{P,m})] \times X_{ijkm} \right]}{X} + A_p$$

The only difference between these formulae is the base rate used (i.e., the former uses B_S and the latter uses B_P).

Rearranging the terms and dividing one formula by the other yields:

$$\frac{(\overline{P_P} - A_P)}{(\overline{P_S} - A_P)} = \frac{B_P}{B_S}.$$

Thus, the proposed base rate in the extension of exposure method is derived by adjusting the seed base rate as follows:

$$B_P = B_S \times \frac{(\overline{P_P} - A_P)}{(\overline{P_S} - A_P)}.$$

If no fixed expense fee or other additive premium applies, the calculation of the proposed base rate is simple:

$$B_P = B_S \times \frac{\overline{P_P}}{\overline{P_S}}.$$

The table below summarizes the calculation of the proposed base rate in the example, according to the formula provided earlier:

14.5 Proposed Base Rate (Extension of Exposures)

(1) Seed Base Rate	$	215.00
(2) Average Premium assuming Seed Base Rate	$	246.83
(3) Proposed Fixed Fee	$	25.00
(4) Proposed Average Premium	$	250.00
(5) Proposed Base Rate	$	218.07

(2)= from Table 14.4, Row (7)
(5)= (1) x [(4) - (3)] /[(2) - (3)]

If the loss ratio method is used to calculate an overall rate level indication, the target is a change in average premium rather than an average premium. In this case, the first step is to calculate the proposed average premium based on the selected change (Δ):

$$\overline{P_{\text{P}}} = (1 + \Delta\%) \times \overline{P_{\text{C}}}.$$

This value can then be used in the same base rate derivation formula:

$$B_{\text{P}} = B_S \times \frac{\overline{P_{\text{P}}} - A_{\text{P}}}{\overline{P_S} - A_{\text{P}}} = B_S \times \frac{(1+\Delta\%) \times \overline{P_{\text{C}}} - A_{\text{P}}}{\overline{P_S} - A_{\text{P}}}.$$

In our example, assume the current average premium is $242.13. This value was selected for illustrative purposes. If the current base rate and expense fee is known, then extension of exposures could be undertaken in a manner parallel to Table 14.4 in order to determine the current average premium. If the indicated percent change in average premium is 3.25%, the resulting proposed average premium is $250. The table below uses these inputs to calculate the proposed base rate.

14.6 Proposed Base Rate (Extension of Exposures, Loss Ratio Method)

(1) Target % Change in Average Premium		3.25%
(2) Current Average Premium	$	242.13
(3) Proposed Average Premium	$	250.00
(4) Seed Base Rate	$	215.00
(5) Average Premium assuming Seed Base Rate	$	246.83
(6) Proposed Fixed Fee	$	25.00
(7) Proposed Base Rate	$	218.07

(3)= (1.0 + (1)) x (2)
(7)= (4) x [(3) - (6)] /[(5) - (6)]

Approximated Average Rate Differential Method

It may not be feasible for a company to retrieve the detailed data necessary to undertake the extension of exposures method for deriving the proposed base rate. One alternative method involves estimating the weighted average proposed rate differential across all rating variables (referred to as $\overline{S_{\text{P}}}$).

Recall from the prior section that he formula for the proposed average premium in our example is:

$$\overline{P_{\mathrm{P}}} = B_{\mathrm{P}} \times \frac{\sum_i \sum_j \sum_k \sum_m \left[R1_{\mathrm{P},i} \times R2_{\mathrm{P},j} \times \left(1.0 - D1_{\mathrm{P},k} - D2_{\mathrm{P},m}\right) \times X_{ijkm} \right]}{X} + A_{\mathrm{P}}.$$

In order to simplify the notation, $\overline{S_{\mathrm{P}}}$ is substituted for the weighted average proposed rate differential across all rating variables:

$$\overline{S_{\mathrm{P}}} = \frac{\sum_i \sum_j \sum_k \sum_m \left[R1_{\mathrm{P},i} \times R2_{\mathrm{P},j} \times \left(1.0 - D1_{\mathrm{P},k} - D2_{\mathrm{P},m}\right) \times X_{ijkm} \right]}{X}.$$

The terms can then be rearranged to solve for the proposed base rate:

$$B_{\mathrm{p}} = \frac{\overline{P_{\mathrm{P}}} - A_{\mathrm{P}}}{\overline{S_P}}.$$

When a rating algorithm is purely multiplicative, $\overline{S_{\mathrm{P}}}$ is typically approximated as the product of the exposure-weighted average differentials for each of the rating variables. In our example rating algorithm, which has discounts that are additive in nature, the exposure-weighted average discounts are calculated and subtracted from one before being multiplied by the average differentials of the multiplicative rating variables:

$$\overline{S_{\mathrm{P}}} \approx \frac{\sum_i X_i \times R1_{\mathrm{P},i}}{X} \times \frac{\sum_j X_j \times R2_{\mathrm{P},j}}{X} \times \left[1.0 - \left[\frac{\sum_k X_k \times D1_{\mathrm{P},k}}{X} + \frac{\sum_m X_m \times D2_{\mathrm{P},m}}{X} \right] \right].$$

The following tables show the approximation of $\overline{S_{\mathrm{P}}}$ for the example, using exposures as weights:

14.7 Proposed Differentials Wtd by Exposures

(1) *R1*	(2) Exposures	(3) Proposed Differential
1	152,500	0.9000
2	570,000	1.0000
3	147,000	1.2500
Total	869,500	1.0247

(1) *R2*	(2) Exposures	(3) Proposed Differential
A	235,000	1.0000
B	480,000	0.9500
C	154,500	1.3000
Total	869,500	1.0257

(1) *D1*	(2) Exposures	(3) Proposed Discount
Y	156,625	5.00%
N	712,875	0.00%
Total	869,500	0.90%

(1) *D2*	(2) Exposures	(3) Proposed Discount
Y	153,625	5.00%
N	715,875	0.00%
Total	869,500	0.88%

(4)	$\tilde{\bar{S}}_P$	1.0323

(Tot3) = (3) weighted by (2)

(4) = $(Tot3_{R1}) \times (Tot3_{R2}) \times (1.0 - Tot3_{D1} - Tot3_{D2})$

The proposed base rate assuming the exposure-weighted average proposed rate differential across all rating variables from Table 14.7 is:

$$B_p = \frac{\overline{P_P} - A_P}{\overline{S_P}} = \frac{\$250 - \$25}{1.0323} = \$217.96.$$

This proposed base rate ($217.96) is different than that which was calculated using the extension of exposures method ($218.07). Exposure-weighting each variable's differentials independently and then combining those averages according to the structure of the rating algorithm ignores the dependence of the exposure distribution by level of one rating variable on the level of another rating variable (i.e., the distributional bias between variables, as discussed in Chapters 9 and 10). The example data was not largely biased, but in practice the bias can drive larger discrepancies in the proposed base rate. One way to mitigate this bias is to use variable premium at current rate level and at base level instead of exposures for weights in the approximation. Recall that variable premium is the premium before addition of any fixed expense fees or other additive premium. The current rate level adjustment for the premium in this analysis should be done at the class level (i.e., applying the parallelogram method to fully aggregated data would not be suitable). The phrase "at base level" means that the variable premium for non-base levels is adjusted to remove the effect of the current rate differential. For multiplicative factors this means dividing the variable premium for each non-base level by the current rate differential for the given variable. Assuming the rating algorithm is entirely multiplicative and the current rate level adjustment is not too time-consuming, calculating variable premium at base level may be a feasible improvement. When the rating algorithm has both multiplicative and additive components, the derivation of variable premium at current rate level and at base level becomes so challenging that the effort to improve the approximation would be better spent compiling data to undertake the extension of exposures technique.

Approximated Change in Average Rate Differential Method

One of the issues with this approximated average rate differential method is that the actuary needs to calculate the weighted average proposed rate relativities for each rating variable. When the variable premium portion of the rating algorithm is entirely multiplicative, the actuary may prefer to estimate the change in the average rate differential; by doing so, the actuary can focus solely on the rating variables that are changing**.**

Recall that the proposed average premium is the current average premium multiplied by the proposed overall change in average premium:

$$\overline{P_{\mathrm{P}}} = (1.0 + \Delta\%) \times \overline{P_{\mathrm{C}}}.$$

The proposed overall change in average premium is comprised of changes to the variable and additive premium components. Using the notation $\Delta_{\mathrm{V}}\%$ and $\Delta_{\mathrm{A}}\%$ to indicate the percentage changes to the variable and additive premium components, respectively, the formula can be transformed:

$$\overline{P_{\mathrm{P}}} = (1.0 + \Delta_{\mathrm{V}}\%) \times (\overline{P_{\mathrm{C}}} - A_{\mathrm{C}}) + (1.0 + \Delta_{\mathrm{A}}\%) \times (A_{\mathrm{C}}).$$

Taking into account that the last term on the right side of the equation is equivalent to the proposed additive premium per exposure, A_{P}, this equation can be rewritten as follows:

$$\overline{P_{\mathrm{P}}} - A_{\mathrm{P}} = (1.0 + \Delta_{\mathrm{V}}\%) \times (\overline{P_{\mathrm{C}}} - A_{\mathrm{C}}).$$

This can be further simplified to show the proposed change in variable premium given the overall change, the current average premium, and the current and proposed additive premium:

$$(1.0 + \Delta_{\mathrm{V}}\%) = \frac{\overline{P_{\mathrm{P}}} - A_{\mathrm{P}}}{\overline{P_{\mathrm{C}}} - A_{\mathrm{C}}} = \frac{(1.0 + \Delta\%) \times \overline{P_{\mathrm{C}}} - A_{\mathrm{P}}}{\overline{P_{\mathrm{C}}} - A_{\mathrm{C}}}.$$

The change in variable premium is comprised of the change in base rate and the change in the average rate differential across all variables:

$$(1.0+\Delta_{\text{V}}\%)=\frac{B_{\text{P}}}{B_{\text{C}}}\times\frac{\overline{S_{\text{P}}}}{\overline{S_{\text{C}}}}.$$

By substituting and reordering terms, the base rate adjustment is defined as follows:

$$\frac{B_{\text{P}}}{B_{\text{C}}}=\frac{(1.0+\Delta\%)\times\overline{P_{\text{C}}}-A_{\text{P}}}{\overline{P_{\text{C}}}-A_{\text{C}}}\times\frac{\overline{S_{\text{C}}}}{\overline{S_{\text{P}}}}.$$

Using $\Delta_{\text{B}}\%$ and $\Delta_{\text{S}}\%$ to represent the percentage base rate change and the percentage change in average rate differential, the equation becomes:

$$1.0+\Delta_{\text{B}}\%=\frac{(1.0+\Delta\%)\times\overline{P_{\text{C}}}-A_{\text{P}}}{\overline{P_{\text{C}}}-A_{\text{C}}}\times\frac{1.0}{(1.0+\Delta_{\text{S}}\%)}.$$

The final term of the equation, which is the reciprocal of one plus the change in average rate differential, is commonly referred to as the **off-balance factor**. It is called that as it represents the amount the base rate needs to be adjusted to balance the changes in the rate differentials.

The only component of the formulae above not previously discussed is the calculation of the change in the average rate differential across all variables (Δ_{S}). An exact calculation of Δ_{S} can be made using the extension of exposures method described earlier in this section. When data at that level of detail is not available, the change in average rate differential needs to be approximated.

When the rating algorithm is entirely multiplicative, the formula for the approximated average rate differential across all variables is shown below (the subscript *w* refers to each rating variable). Only multiplicative variables that are changing need to be considered in the product.

$$1.0+\Delta_{\text{S}}\%\approx\prod_{w}(1.0+\Delta_{\text{S},w}\%).$$

The change in average rate differential for each multiplicative rating variable is calculated as the change in the rate differential for each level of the rating variable weighted by the current variable premium. The formula for the change in average rate differential for *R*1 is given below:

$$(1.0+\Delta_{\text{S},R1}\%)=\frac{\sum_{i}\frac{R1_{\text{P},i}}{R1_{\text{C},i}}\times\left(P_{\text{C},i}-A_{\text{C}}\right)}{\sum_{i}(P_{\text{C},i}-A_{\text{C}})}$$

Said in another way, this formula is simply the change in the current variable premium due to the change in the rate differentials for the given rating variable.

The use of variable premium as weights may be difficult for various reasons. First, it may be difficult to obtain the current variable premium data (particularly at current rate level). Second, weighting by variable premium is challenging when a rating algorithm has additive components. For these reasons, actuaries may choose to measure the average change in rating differentials using exposures as weights.

This method of weighting introduces the same distributional bias as discussed in the previous section, but it may be the most feasible alternative.

In the example rating algorithm, the additive discounts can be combined and restated as a single multiplicative variable (i.e., 1-*D*1-*D*2). The formula for the average rate differential across all variables in the example is as follows:

$$1.0 + \Delta_S\% \approx (1.0 + \Delta_{S,R1}\%)\ x\ (1.0 + \Delta_{S,R2}\%)\ x\ (1.0 + \Delta_{S,(1-D1-D2)}\%)$$

Actuaries approximate the average rate differential changes for multiplicative variables (e.g., *R*1) as follows:

$$(1.0 + \Delta_{S,R1}\%) \approx \frac{\overline{R1}_P}{\overline{R1}_C},$$

where the current and proposed average differentials are determined using exposures as weights:

$$\overline{R1}_P \approx \frac{\sum_i R1_{P,i} \times X_i}{X} \text{ and } \overline{R1}_C \approx \frac{\sum_i R1_{C,i} \times X_i}{X}.$$

The change in (1-*D*1-*D*2) can be approximated as follows:

$$(1.0 + \Delta_{S,(1-D1-D2)}\%) \approx \frac{1 - \overline{D1}_P - \overline{D2}_P}{1 - \overline{D1}_C - \overline{D2}_C},$$

where the current and proposed average discounts are determined using exposures as weights, as shown below for *D*1:

$$\overline{D1}_P \approx \frac{\sum_i D1_{P,i} \times X_i}{X} \text{ and } \overline{D1}_C \approx \frac{\sum_i D1_{C,i} \times X_i}{X},$$

The following table shows the approximation of the average change in differentials ($(1.0 + \Delta_S\%)$ for the example using exposures as weights.

14.8 Proposed Average Change in Differentials

(1) *D*1	(2) Exposures	(3) Current Discount	(4) Proposed Discount
Y	156,625	5.00%	5.00%
N	712,875	0.00%	0.00%
Total	869,500	0.90%	0.90%

(1) *D*2	(2) Exposures	(3) Current Discount	(4) Proposed Discount
Y	153,625	10.00%	5.00%
N	715,875	0.00%	0.00%
Total	$ 869,500	1.77%	0.88%

(Tot3) = (3) Weighted by (2)
(Tot4) = (4) Weighted by (2)

(5) *R*1	(6) Exposures	(7) Current Differential	(8) Proposed Differential	(9) Proposed / Current
1	152,500	0.8000	0.9000	1.1250
2	570,000	1.0000	1.0000	1.0000
3	147,000	1.2000	1.2500	1.0417
Total	869,500	0.9987	1.0247	1.0260

(5) *R*2	(6) Exposures	(7) Current Differential	(8) Proposed Differential	(9) Proposed / Current
A	235,000	1.0000	1.0000	1.0000
B	480,000	1.0500	0.9500	0.9048
C	154,500	1.2000	1.3000	1.0833
Total	869,500	1.0631	1.0257	0.9648

(10) 1-*D*1-*D*2	(11) Exposures	(12) Current Differential (1-*D*1-*D*2)	(13) Proposed Differential (1-*D*1-*D*2)	(14) Proposed / Current
Total	(8) / (7)	0.9733	0.9822	1.0091
	(15) Average Change in Differential			0.9989

(9)= (8) / (7)
(Tot9)= (9) Weighted by (6)
(12)= 1 - ($Tot3_{D1}$) - ($Tot3_{D2}$)
(13)= 1 - ($Tot4_{D1}$) - ($Tot4_{D2}$)
(14)= (13) / (12)
(15) = ($Tot9_{R1}$) x ($Tot9_{R2}$) x (Tot14)

Using the results from Table 14.8 and the previously derived formula:

$$1.0 + \Delta_B\% = \frac{(1.0 + \Delta\%) \times \overline{P}_C - A_P}{\overline{P}_C - A_C} \times \frac{1.0}{(1.0 + \Delta_S\%)},$$

the proposed base rate can be calculated as shown in the following table.

14.9 Proposed Base Rate (Approximated Method)

(1) Current Base Rate	$	210.00
(2) Current Average Premium	$	242.13
(3) Target Change in Average Premium		3.25%
(4) Proposed Average Premium	$	250.00
(5) Proposed Additive Premium (same as Current)	$	25.00
(6) Average Rating Differential Adjustment		0.9989
(7) Proposed Base Rate Adjustment		1.0374
(8) Proposed Base Rate	$	217.85

(4)= (1.0 + (3)) x (2)
(7)= [(4) - (5)] / [(2) - (5)] x [1.0 / (6)]
(8)= (1) x (7)

Other Considerations

Minimum Premium

Some rating algorithms have a minimum premium requirement. The minimum premium requirement is intended to ensure that, on an individual risk basis, premium covers the expected fixed expenses plus some minimum expected loss, as determined by the company. In most cases, companies that use a minimum premium requirement do not have additive fixed expense fees in their rating algorithms. Implementation of a minimum premium requirement can effectively increase total premium. The effect is calculated as follows:

$$\text{Effect} = \frac{\text{Premium With Minimum}}{\text{Premium Without Minimum}} - 1.0.$$

To offset this increase in premium, the otherwise applicable base rate should be multiplied by the following factor:

$$\text{Offset Factor} = \frac{1.0}{1.0 + \text{Effect}}.$$

Limiting the Premium Effect of a Single Variable

In practice, actuaries may decide to limit the premium impact caused by the change in rate differentials for a single rating variable. For example, the actuary may perform a territorial analysis and determine a set of proposed relativities. After taking into account other business considerations (e.g., marketing) as discussed in Chapter 13, the actuary may decide to limit or "cap" the premium impact on any one territory by adjusting the proposed relativities. If the actuary caps the proposed relativity for any one territory, this will reduce the proposed average rate differential across all territories, which will necessitate an offsetting increase in the proposed base rate in order to achieve the target average premium. The extent of the increase will depend on the magnitude of the capping and the number of insureds affected by the cap.

The following example outlines a rate change scenario in which the insurer is targeting an overall rate level change of 15.0%. As part of the rate change, the insurer is revising relativities for a particular rating variable, and management requires that the premium increase for any level of this variable not exceed 20%.

Table 14.10 shows the current and selected relativities (prior to capping) in Columns (3) and (4). These relativity changes would result in an off-balance factor of 0.9749 (= 1 / (1 + 2.57%)). (For simplicity, the example assumes that there is no additive premium.) The total change to each level is the product of the relativity change factor, the off-balance factor, and the target overall change factor, as displayed in Column (8).

14.10 Rate Change Before Capping

(1) Level	(2) Premium	(3) Current	(4) Selected	(5) Relativity Change	(6) Off-Balance Factor	(7) Selected Overall Change	(8) Total Change	(9) Premium on Proposed Rates
1	$ 138,000	0.8000	0.9000	12.50%	0.9749	15.00%	26.13%	$ 174,059
2	$ 659,000	1.0000	1.0000	0.00%	0.9749	15.00%	12.11%	$ 738,805
3	$ 203,000	1.2000	1.2500	4.17%	0.9749	15.00%	16.79%	$ 237,084
Total	$ 1,000,000			2.57%	0.9749	15.00%	14.99%	$ 1,149,948

(5)= (4) / (3) - 1.0
(Tot5)= (5) weighted by (2)
(6)= 1.0 / (1.0 + (Tot5))
(8)= [1.0 + (5)] x (6) x [1.0 + (7)] - 1.0
(9)= (2) x (1.0 + (8))

The total change for Level 1 is 26.13%, which exceeds the desired maximum change of 20.0%. The new capped relativity for Level 1 (refer to this as *X*) is determined such that the product of the relativity change factor (new capped relativity for Level 1 / current relativity for Level 1 = *X* / 0.8000), the off-balance factor (0.9749), and the overall change factor (1.1500) results in a 20% total change. The new capped relativity for Level 1 (*X*) that satisfies this equation is 0.8563.

If the total change for Level 1 were limited to 20.0%, the premium achieved would be $165,600 (=$138,000 x 1.20). This presents a shortfall of $8,459 (=$174,059 - $165,600) which will need to be made up by charging the other levels (Levels 2 and 3) higher premium. The premium proposed for Levels 2 and 3 is $975,889 (= $738,805 + $237,084). This premium must be increased to cover the $8,459 shortfall. One way to achieve this is to increase the base rate by 0.87% (=$8,459 / $975,889).

Since all levels are affected by any base rate change, one problem remains. If the base rate is being increased by 0.87%, this means the premium for capped Level 1 will increase beyond the desired 20% limit. Therefore, the capped relativity for Level 1 must be further reduced by 0.87% to essentially undo the effect of the base rate increase on this level. This adjustment results in a relativity for Level 1 of 0.8489 (= 0.8563 / 1.0087).

Table 14.11 summarizes these calculations.

14.11 Rate Change After Capping Non-Base Level at 20%

(1) Level	(2) Premium	(3) Current	(4) Selected	(5) Relativity Change	(6) Off-Balance Factor	(7) Selected Overall Change	(8) Total Change	(9) Premium Shortfall if Total Change Capped to 20%
1	$ 138,000	0.8000	0.9000	12.50%	0.9749	15.00%	26.13%	$ 8,459
2	$ 659,000	1.0000	1.0000	0.00%	0.9749	15.00%	12.11%	$ -
3	$ 203,000	1.2000	1.2500	4.17%	0.9749	15.00%	16.79%	$ -
Total	$ 1,000,000			2.57%	0.9749	15.00%	14.99%	$ 8,459

(10)	**Proposed Premium from Non-capped Levels (2, 3)**	$ 975,889
(11)	**Proposed Level 1 Relativity to Comply with Cap**	0.8563
(12)	**Base Rate Adjustment to Cover Shortfall**	1.0087
(13)	**Proposed Level 1 Relativity Further Adjusted for Base Rate Offset**	0.8489

(5)= (4) / (3) - 1.0
(Tot5)= (5) weighted by (2)
(6)= 1.0 / (1.0 + (Tot5))
(8)= [1.0 + (5)] x (6) x [1.0 + (7)] - 1.0
(9)= max of [(2) x ((1.0 + (8))] - [(2) x (1.0 + 20%)] and 0
(10)= (2) x (1+(8)) summed over Levels 2 and 3
(11)= [(1.0 + 20%) / (($6_{\text{Row 1}}$) x (1.0 + ($7_{\text{Row 1}}$))] x ($3_{\text{Row 1}}$)
(12)= 1.0 + (Tot9) / (10)
(13)= (11) / (12)

The final base rate offset factor would be the original off-balance factor (0.9749) times the base rate adjustment to cover the premium shortfall from capping (1.0087). The revision to the Level 1 relativity achieves the 20% desired cap, and the adjustment to the base rate ensures the overall change is still 15.0%.

The calculations are a little different if capping is necessary for the base class. Table 14.12 shows a rate change scenario (with the same selected overall change and same premium capping requirement) in which the base class exceeds the premium cap.

14.12 Rate Change Before Capping Base Level Impact

(1) Level	(2) Premium	(3) Current	(4) Selected	(5) Differential Change	(6) Off-balance Factor	(7) Selected Overall Change	(8) Total Change	(9) Premium on Proposed Rates
1	$ 138,000	0.8000	0.6500	-18.75%	1.0541	15.00%	-1.51%	$ 135,916
2	$ 659,000	1.0000	1.0000	0.00%	1.0541	15.00%	21.22%	$ 798,840
3	$ 203,000	1.2000	1.0500	-12.50%	1.0541	15.00%	6.07%	$ 215,322
Total	$ 1,000,000			-5.13%	1.0541	15.00%	15.01%	$ 1,150,078

(5)= (4) / (3) - 1.0
(Tot5)= (5) weighted by (2)
(6)= 1.0 / (1.0 + (Tot5))
(8)= [1.0 + (5)] x (6) x [1.0 + (7)] - 1.0
(9)= (2) x (1.0 + (8))

In this case, the base rate is adjusted downward to cap the change for the base level. The non-base relativities are adjusted upward to cover the amount of premium shortfall due to the cap and to offset the effect of the base rate change in the non-base levels. This is explained in detail below.

In order to limit the total change for Level 2 to 20.0%, the base rate is decreased by applying a factor of 0.9899 (= 1.2000 / 1.2122). This results in a shortfall in Level 2 premium of $8,040 (= (21.22% - 20.00%) x $659,000). The premium collected from the non-base levels need to make up for that shortfall. Prior to capping, the premiums from Levels 1 and 3 was $351,238 (=135,916 + 215,322). The relativities for these levels need to increase by 2.29% (=$8,040 / $351,238). Furthermore, the relativities for Level 1 and Level 3 need to be adjusted to negate the effect of the base rate offset. This means the final adjustment factor for these levels' relativities is 1.0333 (=1.0229 / 0.9899).

Table 14.13 summarizes these calculations.

14.13 Rate Change After Capping Non-Base Level at 20%

(1) Level	(2) Premium	(3) Current	(4) Selected	(5) Relativity Change	(6) Off-Balance Factor	(7) Selected Overall Change	(8) Total Change	(9) Premium Shortfall if Total Change Capped to 20%
1	$ 138,000	0.8000	0.6500	-18.75%	1.0541	15.00%	-1.51%	
2	$ 659,000	1.0000	1.0000	0.00%	1.0541	15.00%	21.22%	$ 8,040
3	$ 203,000	1.2000	1.0500	-12.50%	1.0541	15.00%	6.07%	$ -
Total	$ 1,000,000			-5.13%	1.0541	15.00%	15.00%	$ 8,040

(10)	**Base Rate Adjustment to Comply with Cap**	0.9899
(11)	**Premium from Non-capped Levels (1, 3)**	$ 351,238
(12)	**Adjustment to Level 1, 3 Relativities due to Cap**	1.0229
(13)	**Total Adjustment to Level 1, 3 Relativities**	1.0333

(5)= (4) / (3) - 1.0
(Tot5)= (5) weighted by (2)
(6)= 1.0 / (1.0 + (Tot5))
(8)= [1.0 + (5)] x (6) x [1.0 + (7)] - 1.0
(9)= max of [(2) x ((1.0 + (8))] - [(2) x (1.0 + 20%)] and 0
(10)= (1.0 + 20.0%) / (1.0 + ($8_{\text{Row 2}}$))
(11)= (2) x (1+(8)) summed over Levels 1 and 3
(12)= 1.0 + (9) / (11)
(13)= (12) / (10)

Thus, the revised Level 1 differential is 0.6716 (= 0.6500 x 1.0333) and the Level 3 differential is 1.0850 (=1.0500 x 1.0333). The final base rate offset factor would be the original off-balance factor (1.0541) times the base rate adjustment to comply with the cap (0.9899). These changes result in a 15.0% overall change with no level's premium exceeding the 20.0% limit.

Premium Transition Rules

The last section dealt with capping the rate differential change for any one rating variable. Even if caps are used to minimize this effect, the impact on an individual insured's premium can still be quite large if the proposed rate change includes changes to several rating variables. In other words, even if the change for any one rating variable is small, the cumulative effect of the changes to all of the rating variables may be significant.

The company may wish to mitigate the premium impact for any single insured to reduce the probability that the insured shops for a better deal. In addition, a regulation or law may limit the increase an insurance company may offer a renewing insured. The company can try to alter the proposed rates such that no insured's renewal increase exceeds the limit, but that may be practically impossible if the change includes changes to multiple rating variables. Consequently, the company may choose to pursue a premium transition rule.

A premium transition rule dictates the maximum and/or minimum amount of change in premium that an insured can receive at a single renewal. For example, a company may decide to cap the renewal premium increase for each individual insured to 15%. If the company's rate change results in an insured receiving a 20% premium increase, the insured will receive a 15% rate change at the first renewal following the implementation of the rate change, and the remaining 4.3% (= 1.20 / 1.15 - 1.0) at the second renewal.

The following are some key considerations when using a premium transition rule:

- The company needs to determine the maximum and minimum premium change amounts. As discussed in Chapter 13, the company can test various scenarios of minimum and maximum amounts, to determine the optimal selections.
- Typically premium transition rules apply only to premium changes directly resulting from company initiated rate changes. If premium change is affected by a change in risk characteristics (e.g., the insured buys a newer car), the transition rule algorithm must be adjusted to neutralize the effect of the risk characteristics change. For example, the premium change may be calculated as the ratio of new premium on new risk characteristics to old premium on new risk characteristics.
- The length of time necessary to fully transition the renewal portfolio to the manual rates depends on the extent of the proposed rate change and the premium transition rule implemented. The company should try to avoid long transition periods in order to minimize the chances of multiple overlapping transition periods created by multiple rate changes.
- The effect on the average premium level should also be considered and the base rate altered accordingly. The actuary must decide whether the base rate should be set so that the equilibrium is achieved over the whole time the proposed rates are in effect, or by the expected end of the transition period. In other words, if the company is targeting an average premium of $250 and using a premium transition rule that is expected to span two years, then the company needs to decide whether the base rate should be set so that average premium will equal $250 over the two years combined or at the end of the two-year period. If the cap applies equally to premium increases and decreases, and the rate changes are uniformly distributed, this is not an issue. However, that is not normally the case.

Expected Distribution

Whether using extension of exposures or the approximated average rate differential methods to derive base rates, the actuary makes an assumption about the distribution expected during the period the rates will be in effect. Normally, actuaries use the latest in-force distribution as the best estimate of the expected future distribution. If the company intends to non-renew certain policies, this distribution can be adjusted accordingly.

By using the latest in-force distribution to measure the proposed average premium or the proposed average rate differential across all rating variables, the actuary assumes the rate change will not alter the existing portfolio. The validity of that assumption may vary significantly based on the product, market conditions, and the extent of the proposed changes. For example, a small change that applies uniformly to all homeowners insureds will probably have very little impact on the overall distribution. In this case, the actual average premium change will be close to that estimated using the latest in-force distribution. On the other hand, a non-standard auto insurer implementing a significant rate change that varies widely by age of insured may see a significant change in the overall volume and distribution of business (i.e., insureds receiving large rate changes may non-renew their policies). In this case, the actual average premium change realized may be different than proposed using the latest in-force distribution. If all risks are equally profitable, then loss of premium will be offset by a corresponding loss in expected costs, and the overall rate level adequacy will be unaffected. If the risks are not equally profitable, however, then the distributional shift can affect the adequacy of the overall rates.

This is a shortcoming of the standard actuarial techniques. Price optimization techniques, as discussed in Chapter 13, address this issue by taking into consideration how the rate change is expected to affect demand (i.e., volume).

CALCULATING NEW RATES BASED ON BUREAU OR COMPETITOR RATES

Companies writing a brand new insurance product generally do not have the data necessary to project the individual components of the fundamental insurance equation. Consequently, these companies generally rely on information from their other similar products, similar products sold by competitors (if information is publicly available), or information from rating bureaus, and make adjustments accordingly.

If the company has data from a related product or rating bureau, then the pricing actuary may be able to calculate the rates directly using the techniques described under the pure premium approach. The more likely scenario is that the company must use the rates of a competitor or rating bureau as a guide. This requires a copy of the relevant rating manual or rating bureau filing. Even if a competitor's rating manual is publicly available, the underwriting guidelines may not be. To the extent that the competitor varies premium significantly based on underwriting criteria, the rating manual may not describe how these criteria affect the premium. In such cases, the company will need to use judgment to supplement the competitor information.

In addition to the competitor's rating manual, the company should try to obtain information regarding the relative expense levels and profitability of the target competitor. This information can normally be obtained from recent rate filings or from annual statement data. The company can use this information to better estimate the profit expected if it copies the competitor's rates. Since there will be differences in the way the companies operate as well as differences in the distribution of the portfolios, copying a competitor's rates exactly will not guarantee the same results for the company introducing the new product. The company should use judgment to determine a range of outcomes with respect to how much better or worse it expects profit for the new product to be based on the assessment of the company's situation compared to the competitor's situation.

Depending on the situation, the company may simply use the competitor's manual as a starting point and make adjustments based on known or suspected differences. The following are a few examples of potential adjustments.

First, the company may estimate its fixed expenses will be higher or lower than those of the target competitor. In such a case, the company can simply increase or decrease the competitor's expense fee by the appropriate percentage. For example, assume the company estimates its fixed expenses will be 10% lower than the competitor's. If the competitor has an expense fee of $25.00, then the company should implement an expense fee of $22.50, which is equivalent to the target competitor's fee of $25 multiplied by a factor of 0.90 (= 1.0 - 0.10).

Second, the company may estimate its variable expenses will be higher or lower than those of the target competitor. In such a case, the company can adjust the base rate and the expense fee by the ratio of the target competitor's variable permissible loss ratio to the expected variable permissible loss ratio. For example, assume the company plans to use a commission percentage that is 5 percentage points higher than the competitor's but all other variable expenses are expected to be the same. Assuming that the competitor's variable expense ratio is 15% and the target profit percentage for both companies is 5%, then the company should adjust the target competitor's base rate and expense fees by a factor of 1.067 [= (1.0- 0.15 - 0.05) / (1.0 - 0.20 - 0.05)].

Third, the company may believe its expected loss costs will be different than the target competitor's due to operational differences or a lack of experience with the product. In such cases, the company should judgmentally change the base rate to account for the anticipated difference. For example, the company may feel its lack of experience in settling claims for the new product will result in expected costs that are 5% to 10% higher than those of the target competitor's. The company should increase the base rates by 5% to 10% to account for this.

Fourth, the company may want to target a certain segment of the market that the competitor does not seem to be targeting. In such a case, the company may adjust the rate differentials accordingly. For example, if the company aims to write a significant amount of new business in a certain territory, then it may choose to reduce the rate differential in that territory. If any adjustments are made, then the company can adjust the base rate to offset the change in the average territorial differential.

COMMUNICATING AND MONITORING

Prior to implementing a final set of rates, the ratemaking actuary typically communicates the expected rate change effect to key stakeholders such as regulators and company management.

If the proposed rates apply to a brand new product for new insureds, then communication to regulators may be limited to the source of the derivation of rates (e.g., competitor or bureau rates) and some justification for any judgmental adjustments made. Internal decision-makers will likely want to understand the expected profitability and how the proposed rates position the company in the competitive marketplace.

On the other hand, if the company is implementing rate changes that will impact existing policies, then the communications to key stakeholders may be more extensive. Internal management may want to understand some of the assumptions and selections involved in the overall rate level indication or rate differential changes, but more importantly, they will want to understand the impact on competitive position, expected volume, and expected profitability. As discussed in detail in Chapter 13, the actuary will typically prepare competitive comparisons (e.g., percent wins) under the current and final proposed rates, as well as policyholder dislocation analysis for company management (in total as well as by key segments).[51] This information is useful for the marketing, sales, and customer service functions to prepare for any potential repercussions of large policyholder premium impacts or, on the positive side, to focus advertising on customer segments that will be priced more competitively.

In addition, some companies use models to estimate the conversion and retention rates (per individual risk and in aggregate) expected after implementation of a rate change. Once individual risk conversion and retention rates are estimated, models and assumptions can be used to estimate future expected loss costs,

[51] Ideally company management will have seen such analysis prior to the rates being considered final. This analysis is merely confirming the effect of the final proposed set of rates.

premium, and expenses on these risks. This allows calculation of expected profitability after the rate change. This information aids in business forecasting.

Depending on the jurisdiction, regulators may require considerable detail about the methods and assumptions underlying the overall rate level and rate differential indications and selections. Moreover, they too may want to understand the expected policyholder dislocation.

In addition to communicating the effect of the rate change, it is important for the ratemaking actuary to establish a strategy to monitor the actual effect of the rate change against the expected effect. This may involve comparing actual and expected close rates, retention rates, distributions, and claim frequencies against those expected. The comparison allows quick identification of any strong differences, and allows the company to investigate the potential source of any differences and act accordingly.

SUMMARY

Preceding chapters explained how to calculate actuarial indications and discussed reasons that companies may implement something other than what was indicated. If the actuarial analysis indicates that a product has an inadequate rate level, the company can respond with non-pricing solutions (e.g., reduce expected expenses or expected losses) or it can implement a rate change. Much of this chapter focused on rate change solutions, and in particular derivation of the base rate. Two approaches for derivation of the base rate were outlined: extension of exposures and an approximation of the average rate differential across all rating variables.

This chapter also discussed options for calculating rates for a new product. The company actuary typically obtains raw data or rate information on related products (from the same company or a competitor) or from a rating bureau, and adjusts judgmentally.

Finally, the actuary's role in communicating the rate change effect to internal and external stakeholders was discussed, as well as the importance of establishing a strategy to monitor the actual rate change effect as compared to what was expected.

KEY CONCEPTS IN CHAPTER 14

1. Non-pricing solutions to an imbalanced fundamental insurance equation
    a. Reduce expenses
    b. Reduce loss costs

2. Pricing solutions for an existing product
    a. Calculation of additive fixed expense fee and other additive premium
    b. Derivation of base rate
        i. Extension of exposures method
        ii. Approximated average rate differentials method
        iii. Approximated change in average rate differentials method
    c. Other considerations
        i. No fixed expense fees or additive premium
        ii. Minimum premium
        iii. Limit on the premium effect of a single variable
        iv. Premium transition rules
        v. Expected distribution

3. Pricing solutions for a new product
    a. Use of related data, competitor's rates, or bureau rates
    b. Consideration of differences in expected loss, expense, and target segments

4. Communicating rate change effect to key stakeholders
    a. New product
    b. Existing product

CHAPTER 15: COMMERCIAL LINES RATING MECHANISMS

Most of the text thus far has concentrated on manual ratemaking—in other words, determining what rate should be charged average members of homogeneous groups based on similar risk characteristics. For many commercial insurance products, the creation of homogenous groups for ratemaking purposes is not feasible, and without adjustment, individual risk experience can be expected to vary widely around the average group rate. In addition, some commercial risks are sufficiently large that their historical experience can be used in whole or in part to derive an individual rate. Consequently, commercial lines ratemaking employs special techniques that address the heterogeneity and credibility of commercial risks.

This chapter covers the following topics:

- Manual rate modification mechanisms: experience rating and schedule rating
- Rating techniques for large commercial risks: large deductible plans, loss-rated composite rating, and retrospective rating plans

Commercial risks may be subject to one or many of these rating mechanisms.

Examples of each type of rating mechanism are provided.

MANUAL RATE MODIFICATION TECHNIQUES

Manual rate modification techniques rely on past experience and/or risk characteristics not adequately reflected in the manual rate or the past experience. There are two basic types of manual rate modification techniques: experience rating and schedule rating.

Experience Rating

Experience rating is used when an individual insured's past experience, with appropriate adjustments, is determined to be predictive of the future experience. This determination is reflected in eligibility criteria, typically based on size of manual premium. The experience rating adjustment for the future policy period manual premium is equal to a credibility weighting of the adjusted past experience (often referred to as the "experience" component) and some expected results (referred to as the "expected" component). Techniques to derive credibility measures as well as various options to develop the complement of credibility are discussed in Chapter 12.

The experience component and the expected component should be defined consistently. For example, ALAE should be included in the experience component if it was included in the expected component.

The comparison of the experience and expected components can be performed in many different ways:

- Actual paid loss (and ALAE) compared to expected paid loss (and ALAE) for the experience period as of a particular date
- Actual reported loss (and ALAE) compared to expected reported loss (and ALAE) for the experience period as of a particular date
- Projected ultimate loss (and ALAE) compared to expected ultimate loss (and ALAE) for the experience period
- Projected ultimate loss (and ALAE) for the experience period that has been adjusted to current exposure and dollar levels compared to expected ultimate loss (and ALAE) based upon the current exposure and dollar levels

Following is a discussion of the key components of the experience rating formula, including necessary adjustments to each.

Experience Component

First, the ratemaking actuary must determine the length of the historical experience period to be used in the experience rating formula. The experience period usually ranges from two to five policy years, ending with the last complete year. A shorter experience period is more responsive to changes, but more subject to large fluctuations, due to its relative loss immaturity and the reduced aggregate exposure of the shorter period. Conversely, a longer experience period is less responsive to changes but less subject to large fluctuations in the experience.

Second, the historical experience may need to be adjusted for extraordinary losses. Many experience rating plans apply per occurrence caps on the losses in order to exclude unusual or catastrophic losses. This is often referred to as the maximum single limit per occurrence or MSL. The caps could apply to losses only, or could apply to loss and ALAE. If the actual losses are subject to a per occurrence cap, then the expected losses need to be on the same basis. In addition, caps may be applied to the aggregate of all losses in the policy period.

If the experience modification is based on projected ultimate losses, then historical losses and ALAE (assuming that ALAE is included) for each year in the experience period need to be developed to an ultimate level. This is commonly done by applying loss development factors to either paid or reported losses and ALAE (discussed in detail in Chapter 6). The expected losses, to which the projected ultimate losses will be compared, also need to reflect an ultimate level. If capped losses are used, then the loss development factors applied should be developed from data that has also been capped.

Further adjustments to the historical losses are needed if the basis of the experience rating formula is projected ultimate losses at current exposure and dollar levels (i.e., the fourth method of comparison listed above). The adjustments should reflect economic and social inflation (e.g., changes in judicial decisions or litigiousness) as well as changes in risk characteristics (e.g., size and type of entity) and changes in policy limits. First, historical losses are developed to ultimate, trended to current cost levels, and summed across the years. This figure is then compared to the sum of historical exposures by year. If the exposure base is sensitive to inflation (e.g., payroll), the historical exposures should be trended to current levels and then summed. The ratio of trended ultimate losses to exposures at current level is then multiplied by a current exposure measure. Following is an illustration of this calculation:

15.1 Trended Projected Ultimate Losses & ALAE at Current Exposure Level

Policy Year	(1) Trended Ultimate Losses & ALAE	(2) Exposures	(3) Pure Premium	(4) Current Exposures	(5) Projected Ultimate Losses & ALAE @ Current Exposures
2006	$ 2,568,325	688			
2007	$ 1,954,725	564			
2008	$ 1,465,741	414			
Total	$ 5,988,791	1,666	$ 3,594.71	400	$ 1,437,885

(3) = (Tot1) / (Tot2)
(4) = Number of Vehicles Currently Insured
(5) = (Tot3) x (Tot4)

Expected Component

As mentioned above, the expected component should relate to the experience component. This includes not only such items as inclusion of ALAE, but also whether the past or current exposure is considered. For the four comparison combinations listed above, the first three consider past exposure and the fourth considers current exposure.

Expected losses are usually estimated as the product of an expected loss rate and an exposure measure. The expected loss rate is the expected loss cost reflected in the manual rates; moreover, it can reflect either the prior or current period. If the loss rates are needed for a prior period, the expected loss rate can be based on the manual rates for the prior period or based on manual rates for the current period, adjusted to the appropriate dollar level (i.e., de-trended). If the two sets of manual rates are considerably different, the actuary should understand the reason and assess which approach is appropriate for the situation.

Other Considerations

The experience rating modification factor (or experience "mod") may be subjected to maximum or minimum changes. Another consideration in the application of experience rating is when the total premium under the experience rating plan does not equal the total expected premium. The necessary adjustment, often referred to as off-balance correction, is discussed in detail in Chapter 14.

Example Experience Rating Plan – Commercial General Liability

The following example is a simplified version of the experience rating portion of the 1997 Insurance Services Office (ISO) Commercial General Liability Experience and Schedule Rating Plan. References to "company" indicate the insurance company using the experience rating plan. Each insurance company may have different premium and expense assumptions for the same exposures.

The formula for computing the experience rating debit/credit is:

$$\text{CD} = \frac{(\text{AER - EER})}{\text{EER}} \times Z,$$

where

CD	= Credit/debit percentage
AER	= Actual experience ratio (i.e., the experience component)
EER	= Expected experience ratio (i.e., the expected or exposure component)
Z	= Credibility

The following information is pertinent to the example:

- The policy being experience rated is an occurrence policy with an annual term, and the effective date is July 1, 2010.
- The experience period consists of the last three completed policies effective July 1 to June 30 (i.e. annual policies originating in July 2006, 2007, and 2008), evaluated at March 31, 2010.
- Losses are capped at basic limits, and allocated loss adjustment expenses (ALAE) are unlimited.
- A maximum single limit per occurrence (MSL) is applied to the basic limits losses and unlimited ALAE combined.
- The credibility of the company is 0.44.
- The expected experience ratio is 0.888.

Table 15.2 shows the basic calculation of the experience rating debit/credit. Table 15.3 supports the derivation of certain inputs to Table 15.2.

The actual experience is represented by the projected ultimate losses and ALAE for the three-year experience period, which consists of the reported losses and ALAE as of March 31, 2010, [given as 1(a) in Table 15.2] and the expected unreported losses and ALAE at March 31, 2010 (derived in column 8 of Table 15.3). For both the reported and unreported losses and ALAE, losses are capped at basic limits and a maximum single limit per occurrence (MSL) is applied to the basic limited losses and ALAE combined. The company subject basic limit loss and ALAE costs [1(d) in Table 15.2] represent the expected loss and ALAE underlying the current rating manual rates adjusted to the dollar level of the experience period. The adjustment to the dollar level of the experience period is shown in Table 15.3.

The actual experience ratio (AER) is the projected ultimate losses and ALAE (at basic limits and limited by the MSL) divided by the company subject basic limits loss and unlimited ALAE costs. This is a measure of how the company's actual loss experience subject to the experience rating plan limitations was relative to the expected loss experience represented in the current manual rates.

The expected experience ratio (EER) is essentially the complement of an expected deviation of the company's loss costs in the experience rating plan from the loss costs underlying the manual rate. In this example, the deviation is caused by application of the MSL in the experience rating plan.

The experience rating credit/debit is calculated as a credibility weighting of the AER and the EER according to the formula provided earlier:

$$\text{CD} = \frac{(\text{AER - EER})}{\text{EER}} \times Z.$$

An experience credit results in a reduction in premium and an experience debit results in an increase in premium. In the example below, the experience debit would result in a 10.7% increase in premium. This particular plan example does not have any minimums, maximums, or an explicit off-balance correction.

15.2 Experience Credit/Debit Calculation

(1) Experience Components				
	(a)	Reported Losses and ALAE at 3/31/10 Limited by Basic Limits and MSL	$	141,500
	(b)	Expected Unreported Losses and ALAE at 3/31/10 Limited by Basic Limits and MSL	$	58,762
	(c)	Projected Ultimate Losses and ALAE Limited by Basic Limits and MSL	$	200,262
	(d)	Company Subject Basic Limit Loss and ALAE Costs	$	181,366
	(e)	Actual Experience Ratio		1.104
(2) Expected Experience Ratio				0.888
(3) Credibility				0.44
(4) Experience (Credit)/Debit				10.7%

(1a)= given
(1b)= Table 15.3
(1c)= (1a) + (1b)
(1d)= Table 15.3
(1e)= (1c) / (1d)
(2), (3)= Given
(4)= [((1e) - (2)) / (2)] x (3)

Table 15.3 shows the derivation of two elements in Table 15.2: the company subject basic limits loss and unlimited ALAE costs and the expected unreported losses and ALAE.

15.3 Calculation of Expected Unreported Losses and ALAE and Subject Loss Costs

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Policy Period	Coverage	Current Company B/L Loss & ALAE Costs	Detrend Factors	Company Subject B/L Loss & ALAE Costs	Expected Experience Ratio	Expected Percentage B/L Losses & ALAE Unreported at 3/31/10	Expected B/L Losses & ALAE Unreported at 3/31/10
7/1/06-07	Prem/Ops	$ 51,675	0.804	$ 41,547	0.888	0.192	$ 7,084
	Products	$ 18,850	0.839	$ 15,815	0.888	0.426	$ 5,983
7/1/07-08	Prem/Ops	$ 51,675	0.849	$ 43,872	0.888	0.300	$ 11,688
	Products	$ 18,850	0.876	$ 16,513	0.888	0.545	$ 7,992
7/1/08-09	Prem/Ops	$ 51,675	0.897	$ 46,352	0.888	0.394	$ 16,217
	Products	$ 18,850	0.916	$ 17,267	0.888	0.639	$ 9,798
Total				$ 181,366			$ 58,762

(4)= the reciprocal of the loss and ALAE trend.
(5)= (3) x (4)
(6), (7)= given
(8)= (5) x (6) x (7)

The company subject basic limits losses and unlimited ALAE costs (column 5 above) are the product of:

- the current company basic limits loss and ALAE costs (i.e., the loss costs underlying the current manual rates) and
- the detrend factors, which bring current company basic limits loss and ALAE to the average accident date of each of the policy periods in the experience period, using the loss and ALAE trend underlying the current rates.

  The detrend factor for each policy period in the experience period is the reciprocal of the loss and ALAE trend factor. Chapter 6 explained that the purpose of the trend factor is to project historical losses to a future period. The purpose of the detrend factor is to adjust the current loss costs to a historical experience period. For example, the average accident date of the prospective policy period is January 1, 2011. For the policy period beginning July 1, 2008, the length of the detrend period is two years (the length of time between January 1, 2011, and January 1, 2009). For a loss trend of 4.5%, the detrend factor for the 2008 policy period is the reciprocal of the trend plus 1.0, raised to the length of the detrend period [$=0.916 = (1/1.045)^2$].

The expected basic limits losses and ALAE unreported at March 31, 2010, (column 8 above) are the product of the following:

- The company subject basic limits losses and ALAE
- The expected experience ratio (EER)
- The expected percentage basic limits losses and ALAE unreported at March 31, 2010 (note that these are derived from a separate analysis).

Example Experience Rating Plan – Workers Compensation

The majority of U.S. state insurance departments designate The National Council on Compensation Insurance (NCCI) as the licensed rating and statistical organization of workers compensation insurance. The NCCI Experience Rating Plan has unique features that divide losses into primary and excess components. Consider the generic formula, where primary and excess losses are credibility weighted separately:

$$M = \frac{Z_p \times A_p + (1.0 - Z_p) \times E_p + Z_e \times A_e + (1.0 - Z_e) \times E_e}{E},$$

where
M = Experience Modification Factor
A_p = Actual Primary Losses
A_e = Actual Excess Losses
E_p = Expected Primary Losses
E_e = Expected Excess Losses
$E = E_p + E_e$
Z_p = Primary Credibility
Z_e = Excess Credibility

Although algebraically equivalent, the NCCI uses an alternative expression of this formula by substitution of some terms, which is shown below.

$$M = \frac{A_p + w \times A_e + (1.0 - w) \times E_e + B}{E + B},$$

where
B = Ballast Value, which is based on: $Z_p = E / (E + B)$
w = Weighting Value = Z_e / Z_p.

The primary and excess credibility factors are not expressed directly in the NCCI's formula above. The primary credibility factor is a function of the ballast value (B). The excess credibility factor is a function of both the ballast value (B) and the weighting value for excess losses (w). The ballast value and weighting value are obtained from a table based upon the policy's expected losses and both values increase as expected losses increase. Further detail on the derivation of the NCCI formula is beyond the scope of this text.

The experience period consists of the three most recent complete policy years. The actual losses are the reported losses evaluated at 18 months, 30 months, and 42 months from the beginning of the most recent, second most recent and third most recent policy years, respectively. The actual primary losses are capped at $5,000 per loss.

The expected losses are the actual payroll (in hundreds) by class for the experience period multiplied by the expected loss rates by class for the prospective period. The expected loss rates reflect the losses expected to be reported at the respective evaluations of the experience period policies (18, 30, and 42 months). The expected primary losses are the expected losses multiplied by a *D*-ratio, which is the loss elimination ratio at the primary loss limit (determined using the same loss elimination ratio techniques described in Chapter 11).

Following is a sample calculation of the NCCI experience modification factor. In this example, the effective date of the policy being rated is September 1, 2010, and the policy is comprised of only one class code. Table 15.4 lists the actual losses from the last three complete policy years. The losses are separated into primary and excess components. The primary losses are capped at $5,000 and the excess losses are calculated as the portion of each individual loss above $5,000.

15.4 Actual Losses as of 3/31/10

Policy Year	Claim #	(1) Reported Losses	(2) Primary Losses	(3) Excess Losses
9/1/06-07	1	$15,000	$5,000	$10,000
	2	$100,000	$5,000	$95,000
	3	$25,000	$5,000	$20,000
9/1/07-08	1	$45,000	$5,000	$40,000
	2	$50,000	$5,000	$45,000
	3	$10,000	$5,000	$5,000
9/1/08-09	1	$20,000	$5,000	$15,000
	2	$55,000	$5,000	$50,000
Total		$320,000	$40,000	$280,000

(2) = Minimum [(1), $5,000]
(3) = (1) - (2)

Table 15.5 shows the calculation of expected losses based upon payroll and the expected loss rate,[52] which reflects the expected loss as of the policy's evaluation date. The expected losses are separated into the primary and excess components based upon a *D*-ratio.

15.5 Expected Losses

Policy Year	(1) Payroll	(2) Expected Loss Rate	(3) Expected Losses	(4) D-Ratio	(5) Expected Primary Losses	(6) Expected Excess Losses
9/1/06-07	$ 1,956,000	3.52	$ 68,851	0.24	$ 16,524	$ 52,327
9/1/07-08	$ 2,128,000	3.52	$ 74,906	0.24	$ 17,977	$ 56,929
9/1/08-09	$ 2,317,000	3.52	$ 81,558	0.24	$ 19,574	$ 61,984
Total	$ 6,401,000		$ 225,315		$ 54,075	$ 171,240

(3) = [(1) / $100] x (2)
(5) = (3) x (4)
(6) = (3) - (5)

[52] For illustrative simplicity, this example assumes the employer has only one class code in the state; hence, there is only one expected loss rate and one D-Ratio. A typical employer would have payrolls assigned to more than one class code.

Assuming a ballast value (*B*) of $30,000 and a weighting value (*w*) of 0.25, the experience rating modification factor is calculated as follows:

$$M = \frac{\$40{,}000 + [0.25 \times \$280{,}000] + [(1.0 - 0.25) \times \$171{,}240] + \$30{,}000}{\$54{,}075 + \$171{,}240 + \$30{,}000} = 1.051.$$

This experience modification factor, 1.051, would be applied multiplicatively to the policy's standard premium.

Schedule Rating

Schedule rating is another mechanism for modifying the manual rate in commercial lines pricing. Schedule rating is used to alter manual rates to reflect characteristics that are expected to have a material effect on the insured's future loss experience but that are not actually reflected in the manual rate, or (if experience rating applies) not adequately reflected in the prior experience. For example, if a company implements a new loss control program, the expectation is that the expected losses will be lower than that indicated by the actual historical experience; consequently, an underwriter can use schedule rating to reflect this.

Schedule rating is typically applied in the form of percentage credits (reductions) and debits (increases) to the manual rate. The characteristics can be objective (e.g., the number of years a physician has been licensed) or subjective (e.g., quality of company management). Objective characteristics are generally easier to quantify and validate. However, schedule rating often requires significant underwriting judgment. In general, state insurance laws and regulations require that the filed schedule rating guidelines are applied consistently, and documentation is often required to support the application of each credit and debit.

If experience rating is used in addition to schedule rating, then it is important to recognize that a new characteristic (e.g., a newly implemented safety program) reflected in the schedule rating adjustment will eventually be reflected in the loss experience. The key is for the underwriter to avoid double-counting the effect of a risk characteristic in both the experience modification and schedule rating.

Schedule credits and debits are typically subject to an overall maximum modification.

Example Schedule Rating Plan

The following example illustrates a schedule rating plan for workers compensation and employers liability. In this plan, the underwriter has some discretion in applying the credits or debits. There are five categories for which an insured can be eligible for a schedule credit or debit with minimums and maximums specific to each category. Overall maximum credit or debit also applies.

15.6 Schedule Rating Worksheet

Category	Available Range of Modification (Credit to Debit)	Credit Applied	Debit Applied	Reason / Basis
Premises - General Housekeeping - Preventative Maintenance - Workplace Design - Physical Condition	-10% to +10%			
Classification - Exposures not contemplated in class - Hazards peculiar to a classification have been eliminated - Exposure variation due to technology	-15% to +15%			
Medical Facilities - First Aid - Medical Assistance on Site	-5% to +5%			
Safety Organization - Written Safety Program - Emergency and Disaster Plans - Loss Control Programs - Ergonomics	-15% to +15%			
Employees - Pre-employment Physicals - Drug-Free Workplace - New Hire Training - Job-Specific Training	-15% to +15%			
Total				Maximum = 25% (Credit) / Debit

RATING MECHANISMS FOR LARGE COMMERCIAL RISKS

The rating mechanisms described above used past experience or risk characteristics to modify the manual rate. The mechanisms in this section do not modify the manual rate but rather develop a premium for the large commercial entity. These mechanisms include loss-rated composite risks, large deductible policies, and retrospective rating plans.

Composite Rating

In general, composite rating is an administrative tool used to facilitate the rating of large, complex commercial risks. Rather than rating several different commercial coverages using different exposure bases, all coverages are rated using a single composite exposure base. In composite rating plans, an initial deposit premium is based on a composite rate and estimated composite exposures at the beginning of the policy period. The final premium is based on an audit of final composite exposures after the end of the policy period.

The composite rate may be based on manual rates adjusted by schedule rating and/or experience modification (as discussed in the previous section). Depending on the size of the risk, the composite rate can also be based entirely on the insured's prior experience. This latter case, referred to as loss-rated risks, is the focus of this section of the chapter. Specifically, this section will focus on ISO's Composite

Rating Plan for Loss-Rated Risks. It should be noted that some rules specific to ISO's plan have been simplified or omitted because they are beyond the scope of this paper.

Example Composite Rating Plan for Loss-Rated Risks

In ISO's Composite Rating Plan, an insured is eligible for being classified as "loss-rated" if its historical reported losses and allocated loss adjustment expenses over a defined period exceed a specified aggregate dollar amount. The threshold varies based on different combinations of coverage and limits. If eligible, the insured's historical experience is implicitly considered 100% credible for purposes of determining the composite rate.

The process for determining the composite rate for a loss-rated risk is summarized below.

For each type of coverage and for each of the past five completed years of experience, the reported loss and ALAE based on the most recent valuation is developed to ultimate and trended to the average accident date of the proposed policy period:

Trended Ultimate Loss & ALAE by coverage by year =

(Reported Loss & ALAE) x (Development Factor) x (Loss & ALAE Trend Factor).

After the insured selects a composite exposure base to use for rating, the composite exposures for the past five years are measured and, if applicable, trended from the average earned date of the historical policy to the average earned date of the future policy period. It should be noted that the application of a trend depends on the composite exposure base that is selected. Sales and payroll are common commercial lines exposure bases that are inflation-sensitive and are subject to trend; however, the number of vehicle years used in commercial auto does not need to be trended. The trended composite exposure formula is as follows:

Trended Composite Exposure = Composite Exposure x Exposure Trend Factor.

The next step is to estimate the adjusted premium by dividing the trended ultimate loss and ALAE by the expected loss and ALAE ratio for the five-year period. Dividing the loss and ALAE by the expected loss and ALAE ratio incorporates a provision for ULAE, underwriting expenses, and underwriting profit. The formula is as follows:

$$\text{Adjusted Premium} = \frac{\text{Trended Ultimate Loss \& ALAE}}{\text{Expected Loss \& ALAE Ratio}}.$$

The composite rate for the coverage to be written is then determined as follows:

$$\text{Composite Rate} = \frac{\text{Adjusted Premium}}{\text{Trended Composite Exposure}}.$$

It should be noted that for loss-rated risks, the composite rate is not adjusted by any experience rating plan because the insured's own experience has already been reflected in the rate. On the other hand, schedule rating may apply.

Example Calculation

Bob's Rentals is an equipment dealer that sells new and used equipment, operates a repair and service shop, and offers leases and rentals on equipment it owns. The calculation of the commercial general liability (CGL) policy premium for this type of business is generally complex because each of the three operations is rated separately, and the exposure base for each operation is different. The exposure for sales on new and used equipment is receipts (in $000s) attributable only to sales on new and used equipment. The exposure for the repair and service shop is payroll (in $00s) relating to workers in the repair and service shop, and the exposure for leases and rentals is receipts (in $000s) attributable only to leases and rentals.

Bob's Rentals is sufficiently large enough to meet the eligibility requirements for loss rating under ISO's Composite Rating Plan and desires coverage up to $250,000 per occurrence with $500,000 general aggregate for its exposure to commercial general liability.

The following are the last five years of reported losses and ALAE across all three operations, separated into bodily injury and property damage. Amounts are capped at $250,000 per occurrence and evaluated as of December 31, 2008.

15.7 Reported Loss & ALAE a/o 12/31/08

Policy Year	Bodily Injury	Property Damage
7/1/03-04	$ 1,842,705	$ 626,162
7/1/04-05	$ 1,406,353	$ 591,899
7/1/05-06	$ 1,356,511	$ 517,616
7/1/06-07	$ 1,355,545	$ 623,184
7/1/07-08	$ 1,193,012	$ 568,669
Total	$ 7,154,126	$ 2,927,530

Notes:
Amounts are capped at $250,000 per occurrence.
Amounts are valued as of December 31, 2008.
Amounts represent CGL losses from all three operations.

The selected composite exposure base is total receipts (in $000s). Receipts for the last five years for each of the three operations are as follows:

15.8 Receipts

Policy Year	New/Used Equipment	Repair and Service	Lease and Rentals	Total
7/1/03-04	$ 56,498,756	$ 22,599,503	$ 33,899,254	$ 112,997,513
7/1/04-05	$ 58,564,822	$ 23,425,929	$ 35,138,893	$ 117,129,644
7/1/05-06	$ 61,193,878	$ 24,477,551	$ 36,716,327	$ 122,387,756
7/1/06-07	$ 63,245,228	$ 25,298,091	$ 37,947,137	$ 126,490,456
7/1/07-08	$ 65,721,869	$ 26,288,748	$ 39,433,121	$ 131,443,738
Total	$ 305,224,553	$ 122,089,822	$ 183,134,732	$ 610,449,107

Assume the following:

- Loss and ALAE annual trend (for bodily injury and property damage) is 6%.
- Exposure annual trend rate is 4%.
- Expected loss & ALAE ratio is 72%.
- Loss development factors are as follows:

15.9 Development Factors

Age to Ultimate	Bodily Injury	Property Damage
66-Ult	1.10	1.03
54-Ult	1.25	1.10
42-Ult	1.45	1.20
30-Ult	1.70	1.35
18-Ult	1.95	1.50

Using the data and assumptions provided above, calculate the loss-rated composite rate for Bob's Rentals for its upcoming annual policy to be effective July 1, 2009.

The first step is to develop the trend factors to be applied to the loss and ALAE and the exposure base. The average accident date of the proposed policy period is December 31, 2009, and the average accident date of each policy year from the experience period is December 31. Therefore, the length of time between the average accident date of the most recent policy year and the average accident date of the proposed policy period is two years. Based on the assumed trend rates, the trend factors are calculated as follows:

15.10 Trend Factors

Policy Year	(1) Trend Period	(2) Annual Loss & ALAE Trend	(3) Loss & ALAE Trend Factor	(4) Annual Exposure Trend	(5) Exposure Trend Factor
7/1/03-04	6	6.0%	1.4185	4.0%	1.2653
7/1/04-05	5	6.0%	1.3382	4.0%	1.2167
7/1/05-06	4	6.0%	1.2625	4.0%	1.1699
7/1/06-07	3	6.0%	1.1910	4.0%	1.1249
7/1/07-08	2	6.0%	1.1236	4.0%	1.0816

(3) = [1.0 + (2)] ^ (1)
(5) = [1.0 + (4)] ^ (1)

The next step is to estimate the trended ultimate loss and ALAE, which is calculated as follows:

15.11 Trended Ultimate Loss & ALAE

	(1)	(2)	(3)	(4)	(5)	(6)
	Incurred Loss and ALAE		Development Factors		Loss & ALAE	Trended Ultimate Loss &
Policy Year	BI	PD	BI	PD	Trend Factor	ALAE
7/1/03-04	$ 1,842,705	$ 626,162	1.10	1.03	1.4185	$ 3,790,122
7/1/04-05	$ 1,406,353	$ 591,899	1.25	1.10	1.3382	$ 3,223,764
7/1/05-06	$ 1,356,511	$ 517,616	1.45	1.20	1.2625	$ 3,267,451
7/1/06-07	$ 1,355,545	$ 623,184	1.70	1.35	1.1910	$ 3,746,558
7/1/07-08	$ 1,193,012	$ 568,669	1.95	1.50	1.1236	$ 3,572,348
Total	$ 7,154,126	$ 2,927,530				$ 17,600,243

(6) = [(1) x (3) + (2) x (4)] x (5)

The trended composite exposure is equal to the product of the selected composite exposure and the exposure trend factors.

15.12 Trended Composite Exposure

	(1)	(2)	(3)
Policy Year	Total Receipts ($000's)	Exposure Trend Factor	Trended Exposure
7/1/03-04	$ 112,998	1.2653	$ 142,976
7/1/04-05	$ 117,130	1.2167	$ 142,512
7/1/05-06	$ 122,388	1.1699	$ 143,182
7/1/06-07	$ 126,490	1.1249	$ 142,289
7/1/07-08	$ 131,444	1.0816	$ 142,170
Total	$ 610,450		$ 713,129

(1) = Sum of receipts from 15.8
(3) = (1) x (2)

The final calculation of the composite rate is as follows:

15.13 Composite Rate

(1) Trended Ultimate Loss & ALAE	$ 17,600,243
(2) Expected Loss & ALAE Ratio	72.0%
(3) Adjusted Premium	$ 24,444,782
(4) Trended Composite Exposure	$ 713,129
(5) Composite Rate	$ 34.28

(3) = (1) / (2)
(5) = (3) / (4)

Assuming total receipts for the upcoming policy period are estimated to be $142,500,000, then the deposit premium is $4,884,900 (= $142,500 x 34.28). The final premium is calculated according to the audited exposure; any difference from the deposit premium can be charged or credited to the insured.

Large Deductible Policies

It is not uncommon for commercial entities to purchase insurance with deductible clauses similar to those found in personal insurance. For example, a commercial general liability policy may contain a $500 deductible for property coverage. The main purpose of small deductibles is for the insurer to keep premium low by avoiding expenses associated with the processing and investigation of small nuisance or frivolous claims. At some value, however, a deductible can be set high enough so that the insured is bearing significant risk. For example, a large deductible workers compensation insurance policy may have a deductible of $1 million per occurrence. At that level, the expectation is that a significant proportion of claims will fall entirely within the deductible and thus the insured is bearing a significant portion of the risk.

When the deductible is set to a level where the insured is bearing significant risk, either from the expectation of a large number of small claims or a small number of large claims, the following pricing considerations must be addressed in addition to those associated with small deductible pricing:

- **Claims handling:** It must be determined whether the insured or insurer will assume responsibility for handling claims that fall entirely within the deductible. Large deductible policies will vary in their treatment of this issue; in some cases, the insured assumes responsibility but in most cases, the insurer handles all claims. If the insurer assumes responsibility, the premium must be set to cover the cost for all claim handling expenses, even those expenses associated with claims that do not pierce the deductible. If the insured assumes responsibility, the insurer should evaluate the insured's claim handling expertise to determine the likelihood of claims leakage above the deductible; any material increase in expected costs as a result of the insured's inexperience should be reflected in the pricing.
- **Application of the deductible:** The deductible may apply only to losses or to the sum of losses and allocated loss adjustment expenses (ALAE). The calculation of loss elimination ratios should be based on data consistent with the treatment of ALAE in the policy terms.
- **Deductible processing:** In some large deductible policies the insurer is responsible for paying the entire claim and seeking reimbursement for amounts below the deductible from the insured. In these situations, the premium should reflect the cost of invoicing and monitoring deductible activity as well as a provision associated with the risk that the insured may become bankrupt and be unable to pay for any future deductible invoices (i.e., credit risk). In some instances, collateral is received to cover potentially uncollectible deductible amounts; however, it is rare that this credit risk is fully collateralized.
- **Risk margin:** While the proper treatment and computation of profit is beyond the scope of this paper, it should be noted that losses above a large deductible are expected to be more uncertain than losses below the deductible. As a result, the profit margin may need to be adjusted accordingly to reflect the increased risk being assumed by the insurer.

With the exception of these considerations, pricing for a large deductible policy is otherwise the same as pricing a standard deductible, which is addressed in Chapter 11.

Example Calculation

The following example illustrates how to price a large deductible commercial general liability (CGL) policy based on the following provisions and assumptions:

- The deductible is $500,000 per occurrence.
- The insurer will handle all claims, including those that fall entirely below the deductible.
- The use of a deductible is not expected to reduce ALAE costs. ALAE costs are estimated to be 11% of total losses.
- The deductible applies to losses only. The total ground-up losses without recognition of a deductible are estimated to be $1,000,000.
- The fixed expenses are assumed to be $50,000.
- Variable expenses are assumed to be 13% of premium.
- The insurer will make the payments on all claims and will seek reimbursement for amounts below the deductible from the insured. The cost of processing deductibles is estimated to be 4% of the losses below the deductible.
- Deductible recoveries will not be fully collateralized, and the associated credit risk is estimated to be 1% of the expected deductible payments.
- The desired underwriting profit for a full-coverage (i.e., no deductible) premium is 2%. The insurer includes an additional risk margin of 10% of excess losses for policies with a deductible of $500,000.
- The percent of total losses below the deductible (i.e., Loss Elimination Ratio or LER) and the percent of total losses above the deductible (i.e., excess ratio) are summarized in the table below.

15.14 Loss Elimination Ratios

Loss Limit	LER	Excess Ratio [1.0-LER]
$100,000	60%	40%
$250,000	80%	20%
$500,000	95%	5%

The premium for this policy is developed based on the following formula:

$$\text{Premium} = \frac{\text{Losses above Deductible} + \text{ALAE} + \text{Fixed Expense} + \text{Credit Risk} + \text{Risk Margin}}{(1.0 - \text{Variable Expense Provision} - \text{Profit Provision})}.$$

The first step in deriving the premium is to estimate losses above the $500,000 deductible. This calculation is summarized in the table below.

15.15 Estimated Losses

(1) Expected total ground-up losses	$1,000,000
(2) Excess ratio	5%
(3) Estimated losses above deductible (1) x (2)	$50,000

The premium in this example is computed as follows:

15.16 Computation of Premium

(1) Estimated Losses Above the Deductible	$50,000
(2) ALAE	$110,000
(3) Fixed Expenses	
(a) Standard	$50,000
(b) Deductible Processing	$38,000
(4) Credit Risk	$9,500
(5) Risk Margin	$5,000
(6) Variable Expenses and Profit	15%
(7) Premium	$308,824

(1) = Table 15.15, Row (3)
(2) = 11% x Table 15.15, Row (1)
(3a) = Provided
(3b) = 4% x Table 15.15, Row (1) x LER in Table 15.14
(4) = 1% x Table 15.15, Row (1) x LER in Table 15.14
(5) = 10% x (1)
(7) = [(1) + (2) + (3a) + (3b) + (4) + (5)] / [1.0 - (6)]

Retrospective Rating

Unlike the rating mechanisms described above, which use past experience to estimate the premium needed for a prospective policy period, a retrospective rating plan uses the insured's actual experience during the policy period as the basis for determining the premium for that same period. Conceptually, retrospectively rated insurance is similar to self-insurance with the exception that retrospectively rated insurance policies contain provisions that cause the insurer to retain some risk and that affect the timing of payments for costs incurred under the policy. For example, the actual losses used to determine the final retrospective premium may be limited to reduce the effect of any single unusual or catastrophic event. Similarly, the total premium charged may be subject to a minimum and maximum amount, which helps stabilize the year-to-year cost and further protects the insured from exceeding an aggregate cost due to a large number of claims incurred in any one year.

The premium for a retrospectively rated policy typically consists of an initial premium derived at the beginning of the policy period and periodic premium adjustments made after the policy period to reflect information about the actual claims experience for a pre-determined number of adjustments or until the insurer and insured agree.[53] The initial premium and premium adjustments can be structured in many different ways. Three such examples are as follows:

- The initial premium for a retrospectively rated policy may be based on the total expected expenses, profit, and costs associated with any caps. At the end of the policy period, the insured will be billed annually for all losses incurred under the policy after consideration of any capping rules contained in the policy. These adjustments will continue each year for a pre-determined length of time. The annual amount billed is referred to as a premium adjustment.
- The initial premium may be based on expenses, profit, and costs associated with any caps but excluding LAE associated with the policy. In this case, the annual premium adjustments associated with reported losses during the policy period will include a provision for LAE costs. The provision is typically based on a pre-determined percentage chosen to reflect LAE costs.
- The initial premium may be based on an estimate of the final premium under the policy, including provision for total expected ultimate losses and expenses. In this case, the periodic premium adjustments are due to changes in the revised estimate of the final premium based on up-to-date loss information.

In theory, all three examples above should produce the same total premium for a given retrospectively rated policy; however, the amount of the initial premium and premium adjustments will vary, resulting in cash flow timing differences.

Example Retrospective Rating Plan – Workers Compensation

The following example is a simplified illustration of a typical U.S. workers compensation retrospective rating plan. It should be noted that retrospective rating plans tend to have numerous rules and additional computations, which in this example have been simplified or omitted because they are beyond the scope of this paper.

Basic Formula

The basic formula for retrospective premium is as follows:

$$\text{Retro Premium} = [\text{Basic Premium} + \text{Converted Losses}] \times \text{Tax Multiplier},$$
$$\text{where the retro premium is subject to a maximum and minimum.}$$

[53] Due to the long-tailed nature of many commercial lines of insurance, it may take years before the actual claims experience is known with relative certainty.

Basic Premium

The basic premium is given by:

$$\text{Basic Premium} = \left[\text{Expense Allowance} - \text{Expense Provided Through LCF} + \text{Net Insurance Charge}\right] \times \text{Standard Premium},$$

where

$$\text{LCF} = \text{Loss Conversion Factor},$$
$$\text{Expense Provided Through LCF} = \text{Expected Loss Ratio} \times (\text{LCF} - 1.0),$$
$$\text{Net Insurance Charge} = [\text{Insurance Charge} - \text{Insurance Savings}] \times \text{Expected Loss Ratio} \times \text{LCF}.$$

The Basic Premium is intended to provide for:

1. The insurer's target underwriting profit and expenses excluding expenses provided for by the loss conversion factor (LCF) and the tax multiplier;
2. The cost of limiting the retrospective premium to be between the minimum and maximum premium negotiated under the policy.

Expenses

Expenses are introduced into the retro premium formula through three different components: the tax multiplier, the expense allowance, and the LCF. The tax multiplier reflects the cost of premium taxes and related assessments. The expense allowance in the basic premium formula includes target underwriting profit and underwriting expenses (other than premium taxes and assessments that are paid for via the tax multiplier) and expenses that vary with losses. Since a provision for expenses that vary with losses (e.g., loss adjustment expenses) is incorporated in the retro premium formula through the converted losses term, these expenses are eliminated from the basic premium by subtracting out the product of the Expected Loss Ratio x (LCF -1.0).

Converted Losses

$$\text{Converted Losses} = \text{Reported Losses} \times \text{LCF}.$$

The converted losses are the reported losses limited by the selected accident limit (if any) and multiplied by the LCF. The LCF generally adjusts the losses to include the ALAE that is not already included in the losses plus the ULAE. The LCF is negotiated between the insured and insurer.

Standard Premium

Standard premium is the insurance premium for the risk before consideration of the retrospectively rated plan and any premium discount. It is determined on the basis of the exposure, the insurer's rates, the experience modification, and any premium charges excluding premium discount.

Minimum/Maximum Retrospective Premium

The formulae for deriving the minimum and maximum retrospective premium are as follows:

$$\text{Minimum Retro Premium} = \text{Standard Premium} \times \text{Minimum Retro Premium Ratio},$$
$$\text{Maximum Retro Premium} = \text{Standard Premium} \times \text{Maximum Retro Premium Ratio}.$$

The minimum and maximum retrospective premium ratios are subject to negotiation between the insured and insurer.

Insurance Charge and Insurance Savings

As stated earlier, the retrospective premium may be limited by a minimum and a maximum. The application of a minimum and maximum will affect the total premium collected by the insurer and therefore the cost of doing so needs to be considered as part of the determination of the final premium. The insurance charge is the estimate of the cost associated with limiting the retrospective premium to be no higher than the maximum retrospective premium. The insurance savings is the estimate of the savings associated by requiring the retrospective premium to be no lower than the minimum retrospective premium. The insurance charge and insurance savings are contained in a table of values. The derivation of these tables is beyond the scope of this paper; however, it should be noted that the insurance charge and insurance savings are expressed as a percentage of expected unlimited losses. In this example, the impact of the per occurrence loss limitation is incorporated into the values contained within this table; however, there are some instances where the table represents only the effect of the maximum and minimum premiums, and the effect of the per occurrence loss limitation is computed as a separate additional charge.

Example Calculation

The following simple example is intended to demonstrate the basic computations. Assume the following:

- The first computation of the retrospective premium occurs six months after the end of the policy period and annually thereafter until the insurer and insured agree that the latest computation shall be the final computation.
- The policy is an annual policy and the limited reported losses valued as of 18 months are $153,000.
- The hypothetical provisions that apply for a workers compensation retrospective rating plan are given in the first 10 rows of Table 15.17.

The calculation of the retrospective premium is as follows:

15.17 Provisions of Plan

(1) Minimum retrospective premium ratio (negotiated)	60.0%
(2) Maximum retrospective premium ratio (negotiated)	140.0%
(3) Loss Conversion Factor (negotiated)	1.10
(4) Per Accident Loss Limitation (negotiated)	$100,000
(5) Expense Allowance (excludes tax multiplier)	20%
(6) Expected Loss Ratio	65%
(7) Tax Multiplier	1.03
(8) Standard Premium	$769,231
(9) Insurance Charge for Maximum Premium	0.42
(10) Insurance Savings for Minimum Premium	0.03
(11) Basic Premium	$318,346
(12) Converted Losses	$168,300
(13) Preliminary Retrospective Premium	$501,245
(14) Minimum Retrospective Premium	$461,539
(15) Maximum Retrospective Premium	$1,076,923
(16) Retrospective Premium	$501,245

(11) = [(5)-(6) x [(3)-1.0]+[(9)-(10)] x (6) x (3)] x (8)
(12) = $153,000 x (3)
(13) = [(11)+(12)] x (7)
(14) = (1) x (8)
(15) = (2) x (8)
(16) = Min [Max[(13),(14)] , (15)]

SUMMARY

Some commercial risks are sufficiently large such that their experience can be used in whole or in part to derive an individual rate. Special commercial lines rating mechanisms can be divided into two categories: those that modify the manual rate and those that derive premium specifically for the large commercial risk. Manual rate modification plans include experience rating and schedule rating. Experience rating is used when the past loss experience is determined to be reliably predictive of future expected losses. The experience modification factor is based upon a comparison of the actual experience to the expected experience with credibility taken into consideration. The actual experience may be evaluated in several ways, and it is critically important that the actual experience and expected experience are evaluated on a consistent basis before comparison. Schedule rating alters the manual rate according to characteristics that are expected to have a material effect on the insured’s loss experience relative to that assumed in the manual rate or (if experience rating applies) relative to the manual rate modified by experience rating.

Rating mechanisms for large commercial risks include loss-rated composite plans, large deductible policies, and retrospective rating. Loss-rated composite rating plans facilitate rating of large, complex commercial risks through the use of a single, auditable, composite exposure, and derive a rate based entirely on the insured’s prior experience. Large deductible policies are priced similarly to small deductible policies but several special considerations need to be addressed (e.g., how ALAE are treated and whether the profit provision should include a risk margin). Retrospective rating uses the individual entity's experience during the policy period to establish the final rate (within a pre-determined range of minimum and maximum premium).

KEY CONCEPTS IN CHAPTER 15

1. Manual rate modification plans
    a. Experience rating
        i. Actual experience
        ii. Expected experience
        iii. Other considerations
        iv. Examples for CGL and workers compensation
    b. Schedule rating (with example plan for workers compensation and employer's liability)

2. Rating techniques for large commercial risks
    a. ISO loss-rated composite risks (with example for CGL)
    b. Large deductible policies
    c. Retrospective rating plans (with example for workers compensation)

CHAPTER 16: CLAIMS-MADE RATEMAKING

During the 1960s and 1970s, loss trends for many liability lines increased dramatically due to high economic and social inflation, as well as increases in claim frequency. This was especially the case for professional liability insurance including medical malpractice. As discussed in Chapter 6, claims for long-tailed insurance products can take many years to report and settle. Because of the long-tailed nature of professional liability, it took several years before insurance carriers realized that their products were significantly underpriced. Once companies realized their rates were inadequate, they either reduced coverage or filed for large rate increases or did both to try to improve profitability. This delay in recognizing price inadequacy highlights the significant pricing risk that exists for long-tailed insurance products relative to short-tailed ones.

The long period between the occurrence of a claim and the settlement of a claim can be driven by a reporting lag (i.e., the time between the occurrence date and report date), a settlement lag (i.e., the time between the report date and settlement date), or both. From a loss development perspective, reporting lag relates to pure IBNR (claims that are incurred but not reported), and settlement lag relates to IBNER (claims that are incurred but not enough reported). For a product like medical malpractice, it may be many years before an insured becomes aware of a claim and reports it. For example, it may take several years for the physician's error to cause identifiable symptoms. Even after the claim is reported, it may take many years for the claim to be ultimately settled due to factors such as the need for ongoing treatment and lengthy court proceedings.

In an attempt to reduce the pricing risk inherent in professional liability, the industry introduced an alternative to occurrence coverage that minimizes the time between the coverage inception and claim settlement. This alternative is called claims-made coverage. The major difference between claims-made and occurrence coverage is that the coverage trigger is the date the claim is reported rather than the date the event occurs. Consequently, the difference in pricing these products is not in the coverage provided, but rather in the timing of the pricing decisions. When pricing claims-made policies, the actuary only needs to project claims reported during next year's policy period. When pricing occurrence policies for professional liability and other long tail lines, the actuary must consider claims that will be reported many years into the future.

This chapter covers:

- Aggregation of losses by report year and report year lag
- Coverage triggers for claims-made coverage
- The five principles of claims-made policies
- Issues related to coordinating coverage between claims-made and occurrence policies.

REPORT YEAR AGGREGATION

To better understand the difference between claims-made coverage and occurrence coverage, consider the following diagram that categorizes claims by the year reported and the report lag:

16.1 Report Year Aggregation

		Report Year Lag				
		0	**1**	**2**	**3**	**4**
Report Year	**2010**	L(2010,0)	L(2010,1)	L(2010,2)	L(2010,3)	L(2010,4)
	2011	L(2011,0)	L(2011,1)	L(2011,2)	L(2011,3)	L(2011,4)
	2012	L(2012,0)	L(2012,1)	L(2012,2)	L(2012,3)	L(2012,4)
	2013	L(2013,0)	L(2013,1)	L(2013,2)	L(2013,3)	L(2013,4)
	2014	L(2014,0)	L(2014,1)	L(2014,2)	L(2014,3)	L(2014,4)
	2015	L(2015,0)	L(2015,1)	L(2015,2)	L(2015,3)	L(2015,4)

For example, the first entry, L(2010,0), corresponds to a claim that occurs in 2010 and is reported in year 2010 (i.e., there is 0 time lag between when the claim occurred and when it was reported). The entry for L(2012,2) represents a claim that is reported in 2012 after a report lag of two years (i.e., the claim occurred in 2010). More generally, each row corresponds to claims reported in a given year (i.e., the report year), each column corresponds to claims that share the same reporting lag, and each diagonal (top left to bottom right) represents claims that occurred in the same year (i.e., the same accident year). Since occurrence policies provide compensation for claims that occur during the policy period regardless of when the claim is reported, they are aggregated by accident year (i.e., each diagonal in the table).

For example, an annual occurrence policy written on January 1, 2010, covers claims that are incurred during the policy period but may be reported during the policy period or subsequent to the policy period. Stated in a different way, the occurrence policy covers claims reported in 2010 with no report lag, claims reported in 2011 with a one-year report lag, claims reported in 2012 with a two-year report lag, and so on:

$$\text{Occurrence Policy}(2010) = \text{L}(2010,0) + \text{L}(2011,1) + \text{L}(2012,2) + \text{L}(2013,3) + \text{L}(2014,4).$$

Assuming a maximum report lag of *N*, the occurrence policy for year *Y* can be written more generally:

$$\text{Occurrence Policy}(Y) = \sum_{i-0}^{N} L(Y+i,i).$$

Since the coverage trigger for the claims-made policy is the report date, a claims-made policy is represented by the entries in a row. For example, a claims-made policy written on January 1, 2010, covers all claims reported in 2010 regardless of the report lag:

$$\text{Claims-made Policy }(2010) = \text{L}(2010,0) + \text{L}(2010,1) + \text{L}(2010,2) + \text{L}(2010,3) + \text{L}(2010,4).$$

This can be written more generally:

$$\text{Claims-made Policy}(Y) = \sum_{i-0}^{N} L(Y,i).$$

The following chart compares a 2010 claims-made policy (enclosed by the dotted box) and a 2010 occurrence policy (enclosed by the solid diagonal box).

16.2 Comparison of 2010 Claims-Made and Occurrence Policies

		Report Year Lag				
		0	**1**	**2**	**3**	**4**
Report Year	**2010**	L(2010,0)	L(2010,1)	L(2010,2)	L(2010,3)	L(2010,4)
	2011	L(2011,0)	L(2011,1)	L(2011,2)	L(2011,3)	L(2011,4)
	2012	L(2012,0)	L(2012,1)	L(2012,2)	L(2012,3)	L(2012,4)
	2013	L(2013,0)	L(2013,1)	L(2013,2)	L(2013,3)	L(2013,4)
	2014	L(2014,0)	L(2014,1)	L(2014,2)	L(2014,3)	L(2014,4)
	2015	L(2015,0)	L(2015,1)	L(2015,2)	L(2015,3)	L(2015,4)

Claims-made = dashed

Occurrence Policy = solid

PRINCIPLES

In "Rating Claims-Made Insurance Policies" (Marker and Mohl 1980), the authors identify five principles of claims-made policies that provide more detail as to how pricing risk is reduced.

1. A claims-made policy should always cost less than an occurrence policy as long as claim costs are increasing.
2. If there is a sudden, unpredictable change in the underlying trends, the claims-made policy priced based on the prior trend will be closer to the correct price than an occurrence policy based on the prior trend.
3. If there is a sudden, unexpected shift in the reporting pattern, the cost of a mature claims-made policy (i.e., a policy that covers claims reported during the policy period regardless of accident date) will be affected relatively little, if at all, relative to the occurrence policy.
4. Claims-made policies incur no liability for IBNR, so the risk of reserve inadequacy is greatly reduced.
5. The investment income earned from claims-made policies is substantially less than under occurrence policies.

To help illustrate these principles, assume the following:

- Exposure levels are constant.
- The average loss cost for Report Year 2010 is $1,000.
- Loss costs increase by 5% each report year.
- An equal number of incurred claims are reported each year and all claims are reported within five years of occurrence (i.e., 20% reported each year).
- Loss costs do not vary by report year lag. Also, any trends affecting settlement lag have been ignored.

The assumptions are simple to help illustrate the principles. Relaxing the assumptions does not change the conclusions; it merely makes the interpretation more difficult.

The data underlying these assumptions is represented in the following table:

16.3 Example

Report Year	Loss Costs by Report Year Lag 0	1	2	3	4	Claims-made Loss Costs
2010	$ 200.00	$ 200.00	$ 200.00	$ 200.00	$ 200.00	$ 1,000.00
2011	$ 210.00	$ 210.00	$ 210.00	$ 210.00	$ 210.00	$ 1,050.00
2012	$ 220.50	$ 220.50	$ 220.50	$ 220.50	$ 220.50	$ 1,102.50
2013	$ 231.53	$ 231.53	$ 231.53	$ 231.53	$ 231.53	$ 1,157.65
2014	$ 243.10	$ 243.10	$ 243.10	$ 243.10	$ 243.10	$ 1,215.50
2015	$ 255.26	$ 255.26	$ 255.26	$ 255.26	$ 255.26	$ 1,276.30
2016	$ 268.02	$ 268.02	$ 268.02	$ 268.02	$ 268.02	$ 1,340.10
2017	$ 281.42	$ 281.42	$ 281.42	$ 281.42	$ 281.42	$ 1,407.10
2018	$ 295.49	$ 295.49	$ 295.49	$ 295.49	$ 295.49	$ 1,477.45

Accident Year	Occurrence Loss Costs
2010	$ 1,105.13
2011	$ 1,160.39
2012	$ 1,218.41
2013	$ 1,279.33
2014	$ 1,343.29

Principle 1

Principle 1 states "A claims-made policy should always cost less than an occurrence policy as long as claim costs are increasing." Note that this holds true when comparing loss costs from the claims-made policies and the occurrence policies for each individual year in the table above.

This supports the fact that occurrence policies require the actuary to make projections about the settlement of claims that occur further out into the future. An actuary pricing a 2011 occurrence policy has to project the ultimate value of claims that occur in 2011 and may not even be reported until 2015. In contrast, an actuary pricing a 2011 claims-made policy only needs to project the ultimate cost of claims that will be reported in that year. For claims-made policies, there is a shorter period of time between coverage trigger and settlement date. Since short-term projections are more accurate than long-term ones, the pricing risk is significantly reduced with the claims-made policy compared to an occurrence policy.

Principle 2

Principle 2 states "If there is a sudden, unpredictable change in the underlying trends, the claims-made policy priced based on the prior trend will be closer to the correct price than an occurrence policy based on the prior trend."[54]

The following table restates the example assuming the actual loss cost trend by report year is 7% instead of 5%:

[54] The example that supports this principle assumes constant trends by report year. Certain scenarios involving variable and offsetting trends by report year (e.g., trend overstated in one report year and understated in the following year) may violate the principle.

16.4 Unexpected Trend

Report Year	Loss Costs by Report Year Lag 0	1	2	3	4	Claims-made Loss Costs
2010	$ 200.00	$ 200.00	$ 200.00	$ 200.00	$ 200.00	$ 1,000.00
2011	$ 214.00	$ 214.00	$ 214.00	$ 214.00	$ 214.00	$ 1,070.00
2012	$ 228.98	$ 228.98	$ 228.98	$ 228.98	$ 228.98	$ 1,144.90
2013	$ 245.01	$ 245.01	$ 245.01	$ 245.01	$ 245.01	$ 1,225.05
2014	$ 262.16	$ 262.16	$ 262.16	$ 262.16	$ 262.16	$ 1,310.80
2015	$ 280.51	$ 280.51	$ 280.51	$ 280.51	$ 280.51	$ 1,402.55
2016	$ 300.15	$ 300.15	$ 300.15	$ 300.15	$ 300.15	$ 1,500.75
2017	$ 321.16	$ 321.16	$ 321.16	$ 321.16	$ 321.16	$ 1,605.80
2018	$ 343.64	$ 343.64	$ 343.64	$ 343.64	$ 343.64	$ 1,718.20

Accident Year	Occurrence Loss Costs
2010	$ 1,150.15
2011	$ 1,230.66
2012	$ 1,316.81
2013	$ 1,408.99
2014	$ 1,507.62

The unexpected increase in trend resulted in the Report Year 2011 loss cost for the claims-made policy to be 1.9% (=$1,070.00 / $1,050.00 – 1.0) higher than the original estimate in Table 16.3. Compare this to the occurrence policy in which the unexpected trend resulted in an Accident Year 2011 loss cost that is 6.1% (=$1,230.66 / 1,160.39 -1.0) higher than the original estimate. Since occurrence policies cover claims that may be reported much further in the future and such claims are more significantly affected by trend, an error made in the trend selection has more of an impact than for claims-made policies.

Principle 3

Principle 3 states, "If there is a sudden, unexpected shift in the reporting pattern, the cost of a mature claims-made policy will be affected relatively little, if at all, relative to the occurrence policy." Instead of 20% of the claims being reported each year, assume that 5% of the claims are reported one year later than expected, but all claims are reported within five years. As an example, in 2010, $50 of the loss cost shifts from lag 0 to lag 1, $50 of the loss costs from lag 1 shift to lag 2, and so on. Since an equal amount of loss costs are shifting in and out of lag periods 1, 2, and 3, the only impact is on the first and last lag periods.

16.5 Unexpected Reporting Shift

Report Year	Loss Costs by Report Year Lag 0	1	2	3	4	Total all lags
2010	$ 150.00	$ 200.00	$ 200.00	$ 200.00	$ 250.00	$ 1,000.00
2011	$ 157.50	$ 210.00	$ 210.00	$ 210.00	$ 262.50	$ 1,050.00
2012	$ 165.38	$ 220.50	$ 220.50	$ 220.50	$ 275.63	$ 1,102.51
2013	$ 173.64	$ 231.53	$ 231.53	$ 231.53	$ 289.41	$ 1,157.64
2014	$ 182.33	$ 243.10	$ 243.10	$ 243.10	$ 303.88	$ 1,215.51
2015	$ 191.44	$ 255.26	$ 255.26	$ 255.26	$ 319.07	$ 1,276.29
2016	$ 201.02	$ 268.02	$ 268.02	$ 268.02	$ 335.03	$ 1,340.11
2017	$ 211.07	$ 281.42	$ 281.42	$ 281.42	$ 351.78	$ 1,407.11
2018	$ 221.62	$ 295.49	$ 295.49	$ 295.49	$ 369.37	$ 1,477.46

Accident Year	Occurrence Loss Costs
2010	$ 1,115.91
2011	$ 1,171.70
2012	$ 1,230.30
2013	$ 1,291.80
2014	$ 1,356.40

Examining the results, there is no impact on the loss cost estimates for the claims-made policies, but the estimates for the occurrence policies have changed from the original table (Table 16.3). For example, the Accident Year 2011 loss cost estimate for the occurrence policies has changed by 1%
(= ($1,171.70 / $1,160.39) – 1.0).

Principle 4

Principle 4 states, "Claims-made policies incur no liability for IBNR, so the risk of reserve inadequacy is greatly reduced." When pricing occurrence policies, actuaries need to worry about claims that are incurred but not reported (pure IBNR) and claims that are incurred but not enough reported (IBNER). By definition, claims-made policies do not have a pure IBNR component; therefore, the actuary only has to determine an IBNER reserve, and the risk of reserve inadequacy is greatly reduced.

Principle 5

Principle 5 states, "The investment income earned from claims-made policies is substantially less than under occurrence policies." Insurers are required to hold funds (i.e., reserves) to cover expected liabilities. Those reserves include unearned premium reserves, case reserves, IBNR reserves, and IBNER reserves. As discussed in Chapter 7, insurers can invest those funds and earn investment income. Relative to the occurrence policy, the claims-made policy shortens the period of time between collection of premium and payment of claim; consequently, funds invested for a shorter time horizon result in less investment income.

This principle has implications on the pricing risk of claims-made policies. Part of the pricing process is the determination of the underwriting profit that is required to earn a reasonable rate of return after consideration of the investment income earned. When determining the target underwriting profit provision for a claims-made policy, the pricing actuary should take into consideration both the reduced investment income as well as the reduced pricing risk.

DETERMINING RATES

Once the expected loss costs are determined, the rates can be derived using similar techniques to those discussed previously. More detail is beyond the scope of this text, but may be found in "Rating Claims-Made Insurance Policies" (Marker and Mohl, 1980).

COORDINATING POLICIES

Since occurrence and claims-made policies have different coverage triggers, insureds converting from one policy type to the other should be cognizant of coverage overlaps or gaps. As way of example, consider an insured that had an occurrence policy in 2010 and switches to a claims-made policy starting in 2011. As shown in the following diagram, there is overlapping coverage between the occurrence policy and the claims-made policy.

16.6 Comparison of 2010 Claims-Made and Occurrence Policies

Report Year	Report Year Lag 0	1	2	3	4
2010	L(2010,0)	L(2010,1)	L(2010,2)	L(2010,3)	L(2010,4)
2011	L(2011,0)	L(2011,1)	L(2011,2)	L(2011,3)	L(2011,4)
2012	L(2012,0)	L(2012,1)	L(2012,2)	L(2012,3)	L(2012,4)
2013	L(2013,0)	L(2013,1)	L(2013,2)	L(2013,3)	L(2013,4)
2014	L(2014,0)	L(2014,1)	L(2014,2)	L(2014,3)	L(2014,4)
2015	L(2015,0)	L(2015,1)	L(2015,2)	L(2015,3)	L(2015,4)

Claims-made = enclosed by dotted rectangle

Occurrence Policy = shaded

There are several important features of claims-made policies that are intended to coordinate with occurrence policies correctly.

Claims-made policies have a retroactive date. The claims-made coverage only covers claims that occur on or after the retroactive date. To provide complete coverage without overlap, the retroactive date should be coordinated with the expiration of the last occurrence policy.

When the retroactive date is applied to Figure 16.6, the result is Figure 16.7. The insured can purchase a first-year claims-made policy in 2011 with a retroactive date of January 1, 2011. The first-year claims-made policy will only provide coverage for claims that occurred on or after January 1, 2011, and were reported in 2011 (i.e., L(2011,0)). A second-year claims-made policy with a retroactive date of January 1, 2011, will cover L(2012,0) and L(2012,1). This continues until a mature claims-made policy is issued in 2015.

16.7 Coordinating the Switch from Occurrence to Claims-Made Policy

Report Year	Report Year Lag 0	1	2	3	4
2010	L(2010,0)	L(2010,1)	L(2010,2)	L(2010,3)	L(2010,4)
2011	L(2011,0)	L(2011,1)	L(2011,2)	L(2011,3)	L(2011,4)
2012	L(2012,0)	L(2012,1)	L(2012,2)	L(2012,3)	L(2012,4)
2013	L(2013,0)	L(2013,1)	L(2013,2)	L(2013,3)	L(2013,4)
2014	L(2014,0)	L(2014,1)	L(2014,2)	L(2014,3)	L(2014,4)
2015	L(2015,0)	L(2015,1)	L(2015,2)	L(2015,3)	L(2015,4)

Claims-made = enclosed by dotted rectangle

Occurrence Policy = shaded

The rating of claims-made policies employs a factor to recognize the growth in exposure for each successive claims-made policy during the transition; this factor is known as the step factor. The step factor is a percentage of the mature claims-made rate. Determination of the appropriate step factors requires an evaluation of the expected reporting lag and the various factors affecting claim costs during the lag time. Such an evaluation leads to a distribution of costs to each of the lags of a mature claims-made policy.

As an example, consider the mature claims-made policy from 2015 displayed in Table 16.7 above. Loss estimates for L(2015,0), L(2015,1), L(2015,2), L(2015,3) and L(2015,4) expressed as a ratio to the total losses for Report Year 2015 can be used to determine the step factors. The cumulative values of these ratios by year of lag are used to determine the step structure. The table below shows a potential step factor structure for a claims-made policy.

16.8 Step Factors

Claims-Made Year	Step Factor
First	40%
Second	70%
Third	85%
Fourth	95%
Fifth or More	100%

The table implies that 40% of the costs of a mature claims-made policy come from claims that occurred and were reported during that year, 70% of the costs come from claims that occurred during that year and one year prior, and so on. The progression continues until the mature stage is reached.

There is a similar coordination issue when switching from claims-made coverage to an occurrence policy. Consider the example of an insured switching from a claims-made policy to an occurrence policy in 2011.

16.9 Switch from Claims-Made to Occurrence Policy

		Report Year Lag				
		0	1	2	3	4
Report Year	2010	L(2010,0)	L(2010,1)	L(2010,2)	L(2010,3)	L(2010,4)
	2011	L(2011,0)	L(2011,1)	L(2011,2)	L(2011,3)	L(2011,4)
	2012	L(2012,0)	L(2012,1)	L(2012,2)	L(2012,3)	L(2012,4)
	2013	L(2013,0)	L(2013,1)	L(2013,2)	L(2013,3)	L(2013,4)
	2014	L(2014,0)	L(2014,1)	L(2014,2)	L(2014,3)	L(2014,4)
	2015	L(2015,0)	L(2015,1)	L(2015,2)	L(2015,3)	L(2015,4)

Claims-made = enclosed by dotted rectangle

Occurrence Policy Coverage = shaded

This situation creates a coverage gap. More specifically, there is no coverage for claims that occurred before 2011, but were not reported until after the expiration of the last claims-made policy. To address this issue, companies offer an extended reporting endorsement (or tail coverage) that covers claims that occurred but were not reported before the expiration of the last claims-made policy.

16.10 Switch from Claims-Made to Occurrence Policy with Tail Coverage

	Report Year Lag 0	1	2	3	4
Report Year 2010	L(2010,0)	L(2010,1)	L(2010,2)	L(2010,3)	L(2010,4)
2011	L(2011,0)	L(2011,1)	L(2011,2)	L(2011,3)	L(2011,4)
2012	L(2012,0)	L(2012,1)	L(2012,2)	L(2012,3)	L(2012,4)
2013	L(2013,0)	L(2013,1)	L(2013,2)	L(2013,3)	L(2013,4)
2014	L(2014,0)	L(2014,1)	L(2014,2)	L(2014,3)	L(2014,4)
2015	L(2015,0)	L(2015,1)	L(2015,2)	L(2015,3)	L(2015,4)

Claims-made = enclosed by dotted rectangle

Tail Coverage = enclosed by dotted triangle

Occurrence Policy Coverage = shaded

While the example above described the situation of switching from a claims-made policy to an occurrence policy, a gap in coverage can also occur in the case of retirement. If physicians with claims-made policies retire, they need protection against claims that are reported after the expiration of the last claims-made policy. This protection is given by a tail policy that covers losses occurring during the period for which claims-made coverage was in force and that are reported after the insured's last claims-made policy expires.

SUMMARY

In the 1960s and 1970s, professional liability insurers had poor results due to unanticipated inflation and increasing claim frequencies. Because of the long-tailed nature of the product, it took a significant amount of time for insurers to realize and react to the poor results. Insurers introduced claims-made coverage to minimize the likelihood of the same thing happening in the future.

Claims-made policies differ from occurrence policies in that the coverage trigger is the report date as opposed to the accident date. Claims-made policies are able to be priced more accurately because of the shorter forecast period.

As there are different coverage triggers, it is important to carefully consider the interplay of claims-made and occurrence policies when an insured switches from one to the other. Failure to do this can result in overlapping coverage or coverage gaps.

KEY CONCEPTS IN CHAPTER 16

1. Rationale for claims-made coverage

2. Aggregating losses by report year and report lag

3. Coverage triggers for claims-made coverage

4. Five principles of claims-made policies

5. Coordinating coverage
   a. Retroactive date
   b. First- and second-year claims-made policies
   c. Mature claims-made policies
   d. Extended reporting endorsement or tail coverage

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APPENDICES

As mentioned throughout this text, there are a variety of techniques that actuaries employ based on the unique circumstances of the product being priced and the data that is available. The following appendices include real examples taken from various insurance rate filings. As such, some of the procedures may vary from those discussed within the actual text.

The numbers have been color-coded in the documents. Blue font represents inputs, red font represents selections, and black font is used for numbers that are calculated or referenced from another exhibit.

APPENDIX A: AUTO INDICATION

The following exhibits show an example of an overall rate level indication using the loss ratio approach. This example is for the property damage liability coverage of personal automobile insurance in State XX. All policies are semi-annual, and the proposed effective date for the revised rates is January 1, 2017. Rates are expected to be in effect for one year.

The individual exhibits are as follows:

- LR Indication: summarizes the calculation of the overall indicated premium change using the loss ratio method on five accident years of State XX experience evaluated as of March 31, 2016.
- Credibility: derives the credibility measure and complement of credibility to be applied to the experience period indicated rate change using the classical credibility approach and the square-root rule.
- Current Rate Level: details the calculation of the current rate level factors using the parallelogram method.
- Premium Trend: derives premium trend factors using the two-step trending approach.
- Loss Development: displays the selection of the reported loss and ALAE development factors using the chain ladder method.
- Loss Trend: supports the selection of the loss trend factors based on the pattern of historical changes in frequency, severity, and pure premium.
- ULAE Ratio: shows the determination of the ULAE factor based on the historical relationship of paid ULAE to paid losses and ALAE.
- Expense: derives the fixed and variable expense provisions using the premium-based projection method.

LR (LOSS RATIO) INDICATION EXHIBIT

The overall rate level indication on the LR Indication Exhibit is calculated based on the latest five accident years evaluated as of March 31, 2016. A projected loss and LAE ratio is selected and added to the fixed expense provision. This ratio is compared to the variable permissible loss ratio to obtain the overall indicated rate change, which is credibility-weighted with the complement, the trended present rates indication from the prior rate change analysis. Each column of the exhibit is described in detail below. Some inputs are calculated on later exhibits, as noted in the exhibit footnotes.

Columns 1 through 4 show the calculation of the projected earned premium at current rate level. Column 1 includes the earned premium for each of the historical accident years. Column 2 displays the current rate level adjustment factors required to convert the historical earned premium to current rate level. Column 3 includes the premium trend factors used to project the historical earned premium to the levels expected during the period the rates will be in effect. Column 4 is the projected earned premium at current rates, which is calculated as the product of Columns 1 through 3.

Columns 5 through 9 show the calculation of the projected ultimate loss and LAE. Column 5 displays the reported losses and ALAE for each accident year. Column 6 shows the loss development factors used to develop the losses and ALAE to ultimate levels. Column 7 contains the trend factors that will adjust the ultimate losses and ALAE from historical levels to the projected level expected during the period the rates will be in effect. Column 8 contains the ULAE factors used to adjust the reported losses and ALAE for the ULAE. Column 9 shows the ultimate loss and LAE expected during the period the rates will be in effect, which is the product of Columns 5 through 8.

Column 10 is the calculation of the projected loss and LAE ratio for each accident year, and is calculated by dividing the projected ultimate loss and LAE (Column 9) by the projected earned premium at current rate level (Column 4). The 5-year average projected loss ratio is calculated by dividing the sum of Column 9 by the sum of Column 4; this is equivalent to weighting the individual years by the earned premium at current rate level in each year. The selected projected ultimate loss and LAE ratio is based on the five-year average, and is included in Row 11.

Rows 12 through 15 show the underwriting expense and profit items. Row 12 displays the projected fixed expense ratio (as a percentage of premium). Rows 13 through 15 show the calculation of the variable permissible loss ratio. Row 13 contains the variable expense provision (i.e., the variable expenses as a percentage of premium), and Row 14 includes the underwriting profit provision (i.e., target profit as a percentage of premium). Row 15 is the variable permissible loss ratio, which is calculated as 100% minus the sum of Rows 13 and 14; this figure represents the percentage of each premium dollar that is available to pay for losses, LAE, and fixed expenses.

Row 16 is the calculation of the indicated rate change using the formula:

$$\text{Indicated Change} = \frac{\text{Loss \& LAE Ratio} + \text{Fixed Expense Ratio}}{\text{Variable Permissible Loss Ratio}} - 1.0$$

$$= \frac{[\text{Row 11} + \text{Row 12}]}{[\text{Row 15}]} - 1.0.$$

Row 17 shows the credibility to be applied to the indicated rate change. Row 18 shows the trended present rates indication from the prior review, which is used as the complement of credibility. Row 19, the credibility-weighted indication, is the result of weighting the actuarial indication from this review with the complement of credibility based on the trended present rates approach. The selected rate change, shown in Row 20, is the credibility-weighted indicated rate change.

CREDIBILITY EXHIBIT

The credibility measure and the complement of credibility are derived on the Credibility Exhibit. The credibility measure is calculated based on a full credibility standard of 1,082 claims, and the complement of credibility is the residual indication based on the latest rate change and indication (i.e., the “trended present rates” approach to derive complement of credibility, as discussed in Chapter 12).

Rows 1 through 3 show the calculation of the credibility measure. Row 1 displays the number of claims in the experience period. Row 2 shows the full credibility standard for private passenger auto calculated using the classical credibility approach. Row 3 shows the credibility assigned to the historical loss ratio indication. Since the number of claims exceeds the number of claims needed for full credibility, the credibility is 100%.

Rows 4 through 11 display the derivation of the complement of credibility. Rows 4 and 5 show the last indicated rate change and the last rate change taken. Row 6 divides the sum of one plus Row 4 by the sum of one plus Row 5 and then subtracts one; this represents the residual indication. The residual indication is adjusted by the net trend factor. The net trend is calculated by dividing the sum of one and the loss trend (Row 7) by the sum of one and the premium trend (Row 8) and then subtracting one. The trend period is measured from the last rate change effective date (January 1, 2016) to the proposed effective date (January 1, 2017). The trended present rates indication is shown in Row 11 and is used as the complement of credibility.

CURRENT RATE LEVEL EXHIBIT

Historical premium needs to be adjusted to account for any rate changes that have taken place during or after the historical experience period; in other words, the historical premium needs to be adjusted to the rate level currently in effect. The Current Rate Level Exhibit shows the calculation of the current rate level factors using the parallelogram method for each year.

Sheet 1

Sheet 1 shows the derivation of the cumulative rate level indices for each rate level group during or after the historical period. The rate change history is displayed in Columns 1 and 2. The rate level index in Column 3 is the rate change added to one, and the cumulative rate level index in Column 4 is the cumulative product of the indices in Column 3.

Sheet 2

Sheet 2 calculates the current rate level factors. The columns in 1a display the portion of premium earned during each calendar year for each of the individual rate level groups. These figures are calculated based on the assumption that the six-month policies are written uniformly throughout the year. Column 2 shows the average cumulative rate level for each calendar year, which is the cumulative rate level associated with each rate level group weighted by the portion of the calendar year premium represented by the rate level group. Column 3 displays the current rate level index, which is the cumulative rate level in the most recent rate level group. Column 4 is the factor to be applied to earned premium in each calendar year to bring it to current rate level, and is the ratio of Column 3 to Column 2.

PREMIUM TREND EXHIBIT

Historical premium also needs to be adjusted to account for the change in average premium level due to distributional changes in the book of business. The Premium Trend Exhibit shows the calculation of the premium trend factors used in the indication using a two-step trending approach. This exhibit is described in detail below.

Sheets 1-2

Sheet 1 shows the historical annual changes in average written premium at current rate level. Column 3 is the average written premium at current rate level for the 12-month period ending each quarter, and is calculated by dividing the written premium at current rate level (Column 1) by the written exposures (Column 2). It would have been preferable to use the average written premium at current rate level for each quarter (rather than the 12-month rolling quarter), but that data was not readily available. Column 4 calculates an annual trend of average written premium at current rate level (i.e., the percentage change from the prior year). Exponential trends based on various lengths of time are calculated and displayed at the bottom of the sheet. Sheet 2 displays the data in graphical format. The selected projected premium trend is included on Sheet 2. The trend selection is based on the more recent data because this projection is going to be applied to historical premium already trended to the most recent period.

Sheet 3

Sheet 3 shows the derivation of the premium trend factors. Columns 1 and 2 show calendar year earned premium at current rate level and earned exposures, respectively. Average earned premium at current rate level is calculated in Column 3 by dividing Column 1 by Column 2. Column 4 is the most recent average written premium at current rate level from Sheet 1. Column 5 shows the current trend factor, which adjusts the earned premium for each calendar year to the most recent average written premium level; these factors are calculated by dividing Column 4 by Column 3. Column 6 is the selected projected premium trend. Column 7 is the projected trend period, measured from the average written date of the 12 month period ending December 31, 2015 (this is June 30, 2015) to the average written date of PY2017 (June 30, 2017). The projected trend factor is calculated in Column 8 as one plus Column 6, raised to the power of Column 7. Column 9 is the total trend factor that brings historical earned premium at current rate level to the projected level when rates will be in effect, and is calculated as the product of Columns 5 and 8.

LOSS DEVELOPMENT EXHIBIT

Since losses and ALAE in the historical data are not fully mature, they need to be developed. The Loss Development Exhibit shows the calculation of the loss and ALAE development factors using the chain ladder technique. In this exhibit, the historical reported loss and paid ALAE are shown for each accident year at each valuation point. Each row represents the reported loss and paid ALAE for a given accident year with each column representing a specific age of development.

The age-to-age factors, or link ratios, are calculated for each accident year by dividing the reported loss and paid ALAE at one valuation point by the value at the previous valuation point. Rows 1 through 5 show various averages used as guides for selections. The three-, four-, and all-year averages represent straight averages of the link ratios. The average excluding hi-lo represents the straight average of all link ratios after excluding the highest and lowest link ratios. The geometric average is the n^{th} root of the product of the n link ratios used in the average.

Row 6 shows the selected age-to-age factors. Row 7 converts the selected age-to-age factors to age-to-ultimate factors by multiplying each age-to-age factor by all of the subsequent age-to-age factors. For example, the 39-ultimate factor is the product of the selected 39-51, 51-63, and 63-ultimate age-to-age factors.

LOSS TREND EXHIBIT

Because the proposed rates will be in effect in a period later than the historical period, the loss and ALAE need to be adjusted to account for expected trends in the frequency and severity of claims between the two periods. A two-step loss trending approach is used. Regional data is used to determine appropriate trends.

Sheets 1-4

Sheet 1 shows the historical frequencies, severities, and pure premiums. Columns 1 through 3 are the earned exposures, closed claim counts, and paid losses on a rolling 12-month basis (i.e., 12 month period ending each quarter). Changes in paid losses are used as the best estimate of the trend as the use of paid losses eliminates any distortions caused by changes in overall reserve adequacy. LAE are not included with the losses in the trend data, and are therefore assumed to be affected by the same trend. Columns 4 through 6 display the frequency (Column 2 divided by Column 1), severity (Column 3 divided by Column 2), and pure premium (Column 3 divided by Column 1) for each 12-month ending period. Exponential trends are fit to the frequency, severity, and pure premiums columns for various durations. While not displayed, some actuaries may view the *R-squared* statistic to gauge the goodness of fit of the exponential trends, and consider that when making selections.

Sheets 2 through 4 are the graphical representation of this data and the selected trends.

Sheet 5

Sheet 5 shows the derivation of the total loss trend factor. Column 1 shows the selected current loss trend factor, and Column 2 shows the current cost trend period for each accident year, which is the number of years between the average date of loss in the accident year (June 30, 20XX) to the average date of loss for the most recent period used to select the loss trends (June 30, 2015). Column 3 is the sum of one and the selected current pure premium trend from Column 1 trended for the length of time in Column 2. Columns 4 through 6 show a similar calculation to determine the projected pure premium trend factor. In this case, the selected projected pure premium trend is used to trend losses and ALAE from June 30, 2015, to the average date of loss for the projected period (September 30, 2017). Column 7 is the total pure premium loss trend factor and is calculated as the product of Columns 3 and 6.

ULAE RATIO EXHIBIT

In this example, three calendar years of countrywide data are used to determine the factor needed to adjust the State XX reported loss and paid ALAE to include ULAE. Column 1 includes the countrywide calendar year paid loss and ALAE, and Column 2 shows the countrywide calendar year paid ULAE. Calendar year paid information is used as it is readily available accounting data and is not susceptible to changes in reserving practices. Column 3 (Column 2 divided by Column 1) is the paid ULAE as a percentage of paid loss and ALAE. The selection in Row 4 is based on the historical ratios. The selected percentage is converted into a factor in Row 5 by adding one.

EXPENSE EXHIBIT

The underwriting expense ratios are determined using the premium-based projection method. This method assumes that the historical relationship between expenses and premium is expected to continue during the projected period.

The expenses are divided into five categories: general, other acquisition, licenses and fees, commissions and brokerage, and taxes. The calculations and selections are performed for each category separately.

For each of the five categories, Row “a” shows the expense associated with the category for each of the three calendar years. The expense is aggregated either at the state or countrywide level, depending on the category. Row “b” displays the corresponding premium. The premium used in this calculation is either state or countrywide and either written or earned depending on the nature of the expense category. Row “c” is the calculation of the expense ratio for each expense category for each year, as well as the premium-weighted average of the three years; the selected percentage is displayed in the last column. Row “d” contains the percentage selected to split each expense ratio between fixed and variable. Rows “e” and “f” are the resulting fixed and variable expense ratios, respectively, using the selected percentage shown in Row “d.”

Rows 6 and 7 at the bottom of the exhibit are the totals of the fixed and variable expense ratios from summing the individual categories. No expense trend is applied to the fixed expense ratio. This assumes the expenses and premium will trend at the same rate and the ratio will remain constant.

State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
Indicated Rate Change - Loss Ratio Method

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Calendar Accident Year	Earned Premium	Current Rate Level Factor	Premium Trend Factor	Projected Earned Premium at Current Rate Level	Reported Losses and Paid ALAE	Loss Development Factor	Loss Trend Factor	ULAE Factor	Projected Ultimate Losses and LAE	Projected Loss and LAE Ratio
2011	$ 1,122,372	1.2161	1.1342	$ 1,548,088	$ 856,495	1.0000	0.9912	1.143	$ 970,359	62.7%
2012	$ 1,154,508	1.2176	1.1116	$ 1,562,608	$ 867,184	0.9799	0.9962	1.143	$ 967,578	61.9%
2013	$ 1,280,545	1.1311	1.0879	$ 1,575,741	$ 835,120	1.0003	1.0012	1.143	$ 955,974	60.7%
2014	$ 1,369,976	1.0892	1.0663	$ 1,591,109	$ 821,509	1.0282	1.0062	1.143	$ 971,450	61.1%
2015	$ 1,397,750	1.0991	1.0452	$ 1,605,706	$ 797,866	1.0966	1.0113	1.143	$ 1,011,357	63.0%
Total	$ 6,325,151			$ 7,883,252	$ 4,178,174				$ 4,876,718	61.9%

(11)	Selected Projected Loss and LAE Ratio	61.9%
(12)	Fixed Expense Provision	11.3%
(13)	Variable Expense Provision	17.0%
(14)	UW Profit Provision	5.0%
(15)	Variable Permissible Loss Ratio	78.0%
(16)	Indicated Rate Change	-6.2%
(17)	Credibility	100.0%
(18)	Trended Present Rates Indication	6.2%
(19)	Credibility-Weighted Indicated Rate Change	-6.2%
(20)	Selected Rate Change	-6.2%

(2) From Current Rate Level Exhibit - 2
(3) From Premium Trend Exhibit - 3
(4) = (1) x (2) x (3)
(5) Case Incurred Losses and ALAE Evaluated As Of 03/31/2016
(6) From Loss Development Exhibit
(7) From Loss Trend Exhibit - 5
(8) From ULAE Ratio Exhibit
(9) = (5) x (6) x (7) x (8)
(10) = (9) / (4)
(12) From Expense Exhibit
(13) From Expense Exhibit
(14) Selected profit provision
(15) = 100% - (13) - (14)
(16) = { [(11) + (12)] / (15) } - 1.0
(17) From Credibility Exhibit
(18) From Credibility Exhibit
(19) = (16) x (17) + (18) x [1.0 - (17)]

State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
Credibility Calculations

(1)	Total Number of Claims in Historical Period	3,612
(2)	Number of Claims for Full Credibility	1,082
(3)	Credibility Min{ [(1) / (2)] ^ 0.5, 1.0 }	100.0%
(4)	Latest Indicated Rate Change	13.2%
(5)	Last Rate Change Taken From Current Rate Level Exhibit - 2	5.0%
(6)	Residual Indication { [1.0 + (4)] / [1.0 + (5)] } - 1.0	7.8%
(7)	Projected Loss Trend From Loss Trend Exhibit - 1	0.5%
(8)	Projected Premium Trend From Premium Trend Exhibit - 1	2.0%
(9)	Net Trend { [1.0 + (7)] / [1.0 + (8)] } - 1.0	-1.5%
(10)	Trend Period From Last Rate Change Effective Date (01/01/2016) to Proposed Effective Date (01/01/2017)	1.0
(11)	Trended Present Rates Indication { [1.0 + (6)] x [1.0 + (9)] ^ (10) } - 1.0	6.2%

State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
Rate Change History

	(1)	(2)	(3)	(4)
Rate Level Group	Effective Date	Rate Change	Rate Level Index	Cumulative Rate Level Index
A			1.0000	1.0000
B	04/01/2011	-5.0%	0.9500	0.9500
C	07/01/2012	10.0%	1.1000	1.0450
D	10/01/2013	5.0%	1.0500	1.0973
E	07/01/2014	-2.0%	0.9800	1.0754
F	10/01/2015	5.0%	1.0500	1.1292
G	01/01/2016	5.0%	1.0500	1.1857

(3) = 1.0 + (2)
(4) = Cumulative Product of (3)

State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
Calculation of Current Rate Level Factors

	(1a)							(2)	(3)	(4)
	Portion of Earned Premium Assumed in Each Rate Level Group							Average Cumulative	Current Rate Level	
Calendar Year	A	B	C	D	E	F	G	Rate Level	Index	CRL Factor
2011	50.00%	50.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.9750	1.1857	1.2161
2012	0.00%	75.00%	25.00%	0.00%	0.00%	0.00%	0.00%	0.9738	1.1857	1.2176
2013	0.00%	0.00%	93.75%	6.25%	0.00%	0.00%	0.00%	1.0483	1.1857	1.1311
2014	0.00%	0.00%	6.25%	68.75%	25.00%	0.00%	0.00%	1.0886	1.1857	1.0892
2015	0.00%	0.00%	0.00%	0.00%	93.75%	6.25%	0.00%	1.0788	1.1857	1.0991
(1b) Cumulative Rate Level	1.0000	0.9500	1.0450	1.0973	1.0754	1.1292	1.1857			

(1a) Portion of Each Calendar Year's Earned Premium by Rate Level Group
(1b) Cumulative Rate Level for each Rate Level Group
(2) (1b) Weighted by (1a) Within Each Calendar Year
(4) = (3) / (2)

State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
Premium Trend Selection

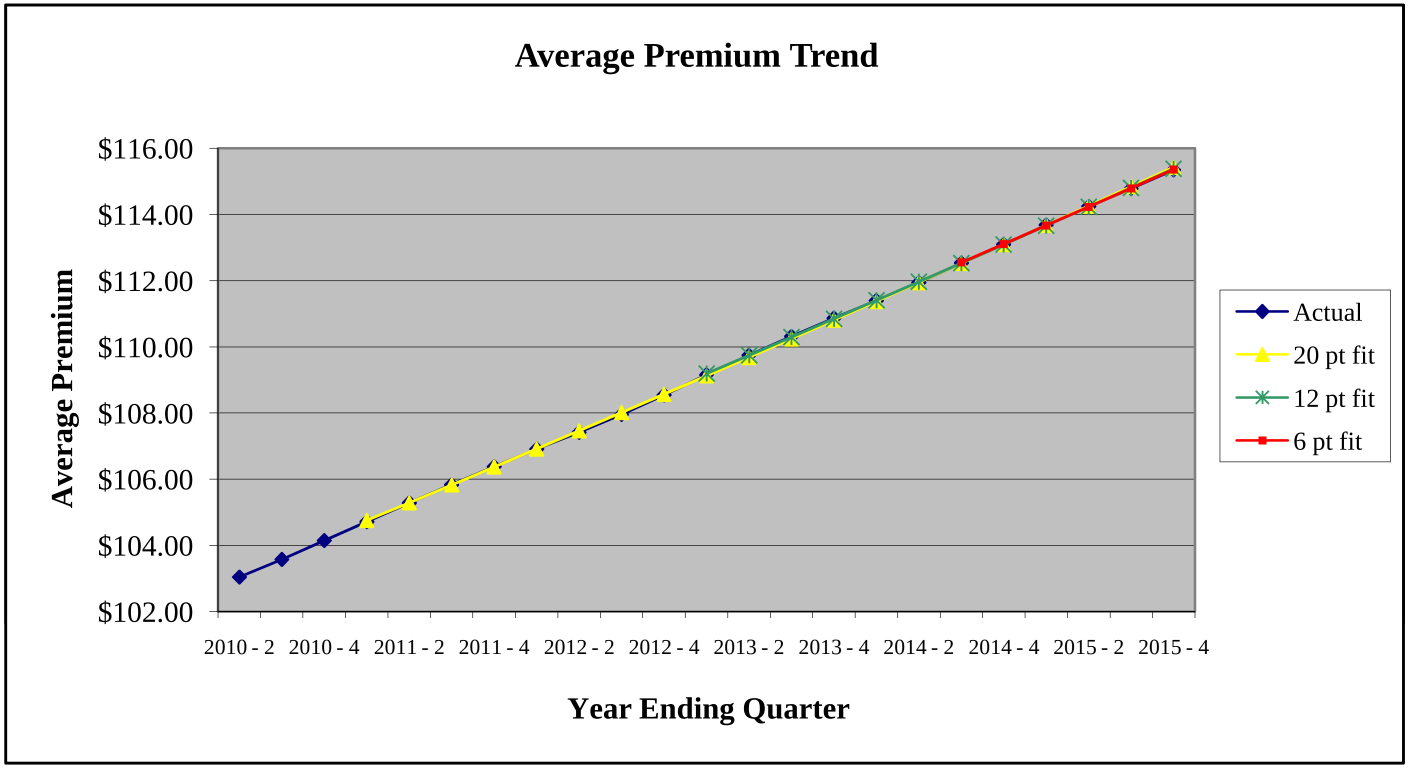
Year Ending Quarter - X	(1) Written Premium at CRL	(2) Written Exposure	(3) Average Written Premium at CRL	(4) Annual Trend
2010 - 2	$1,314,117	12,752	$103.05	
2010 - 3	$1,323,381	12,776	$103.58	
2010 - 4	$1,333,726	12,806	$104.15	
2011 - 1	$1,343,014	12,825	$104.72	
2011 - 2	$1,354,391	12,863	$105.29	2.2%
2011 - 3	$1,364,644	12,893	$105.84	2.2%
2011 - 4	$1,374,283	12,917	$106.39	2.2%
2012 - 1	$1,384,951	12,953	$106.92	2.1%
2012 - 2	$1,393,570	12,973	$107.42	2.0%
2012 - 3	$1,403,987	13,005	$107.96	2.0%
2012 - 4	$1,415,881	13,044	$108.55	2.0%
2013 - 1	$1,428,087	13,082	$109.16	2.1%
2013 - 2	$1,438,647	13,108	$109.75	2.2%
2013 - 3	$1,448,311	13,128	$110.32	2.2%
2013 - 4	$1,458,540	13,155	$110.87	2.1%
2014 - 1	$1,468,617	13,183	$111.40	2.1%
2014 - 2	$1,479,666	13,217	$111.95	2.0%
2014 - 3	$1,492,537	13,262	$112.54	2.0%
2014 - 4	$1,503,294	13,292	$113.10	2.0%
2015 - 1	$1,514,903	13,325	$113.69	2.1%
2015 - 2	$1,524,242	13,341	$114.25	2.1%
2015 - 3	$1,536,215	13,383	$114.79	2.0%
2015 - 4	$1,547,368	13,414	$115.35	2.0%

Exponential Trend	
20 pt	2.1%
16 pt	2.1%
12 pt	2.0%
8 pt	2.0%
6 pt	2.0%
4 pt	1.9%

Selected Projected Premium Trend 2.0%

(3) = (1) / (2)
(4) Percent Change in Avg WP at CRL From Prior Year

State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
Premium Trend



Exponential Trend		Selection
20 pt	2.1%	2.0%
12 pt	2.0%	
6 pt	2.0%	

State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
Premium Trend Calculation

Calendar Year	(1) Earned Premium at CRL	(2) Earned Exposure	(3) Average Earned Premium at CRL	(4) Most Recent Average Written Premium at CRL	(5) Current Trend Factor	(6) Selected Projected Premium Trend	(7) Projected Trend Period	(8) Projected Trend Factor	(9) Total Trend Factor
2011	$1,364,916.59	12,900	$105.81	$115.35	1.0902	2.0%	2.0000	1.0404	1.1342
2012	$1,405,728.94	13,020	$107.97	$115.35	1.0684	2.0%	2.0000	1.0404	1.1116
2013	$1,448,424.45	13,130	$110.31	$115.35	1.0457	2.0%	2.0000	1.0404	1.0879
2014	$1,492,177.86	13,258	$112.55	$115.35	1.0249	2.0%	2.0000	1.0404	1.0663
2015	$1,536,267.03	13,380	$114.82	$115.35	1.0046	2.0%	2.0000	1.0404	1.0452

(1) = [LR Indication Exhibit (1)] x [Current Rate Level Exhibit - 1 (4)]
(3) = (1) / (2)
(4) Average Written Premium for Year Ending 2015, Quarter 4
[From Premium Trend Exhibit - 1]
(5) = (4) / (3)
(6) From Premium Trend Exhibit - 1
(7) From 06/30/2015 to 06/30/2017
(8) = [1.0 + (6)] ^ (7)
(9) = (5) x (8)

State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
Loss Development

Accident Year	15 Months	27 Months	39 Months	51 Months	63 Months
	Reported Losses and Paid ALAE Evaluated As Of				
2009	705,088	725,592	738,686	753,027	732,239
2010	712,475	753,295	782,248	800,258	813,949
2011	714,196	763,913	855,150	874,106	856,495
2012	764,101	861,114	884,498	867,184	
2013	774,384	846,167	835,120		
2014	785,068	821,509			
2015	797,866				

Age-to-Age Factors	15-27	27-39	39-51	51-63	63-Ult
2009	1.0291	1.0180	1.0194	0.9724	
2010	1.0573	1.0384	1.0230	1.0171	
2011	1.0696	1.1194	1.0222	0.9799	
2012	1.1270	1.0272	0.9804		
2013	1.0927	0.9869			
2014	1.0464				
(1) All-Year Average	1.0704	1.0380	1.0113	0.9898	
(2) 3-Year Average	1.0887	1.0445	1.0085	0.9898	
(3) 4-Year Average	1.0839	1.0430	1.0113		
(4) Average Excluding Hi-Lo	1.0665	1.0279	1.0208	0.9799	
(5) Geometric Average	1.0699	1.0371	1.0111	0.9896	
(6) Selected Age-to-Age	1.0665	1.0279	1.0208	0.9799	1.0000
(7) Age-to-Ultimate	1.0966	1.0282	1.0003	0.9799	1.0000

(1) Straight Average
(2) Straight Average
(3) Straight Average
(4) Straight Average Excluding Highest and Lowest Values
(5) = (Product of Age-to-Age Factors) ^ (1.0 / Number of Age-to-Age Factors)
(7) = Cumulative Product of (6)

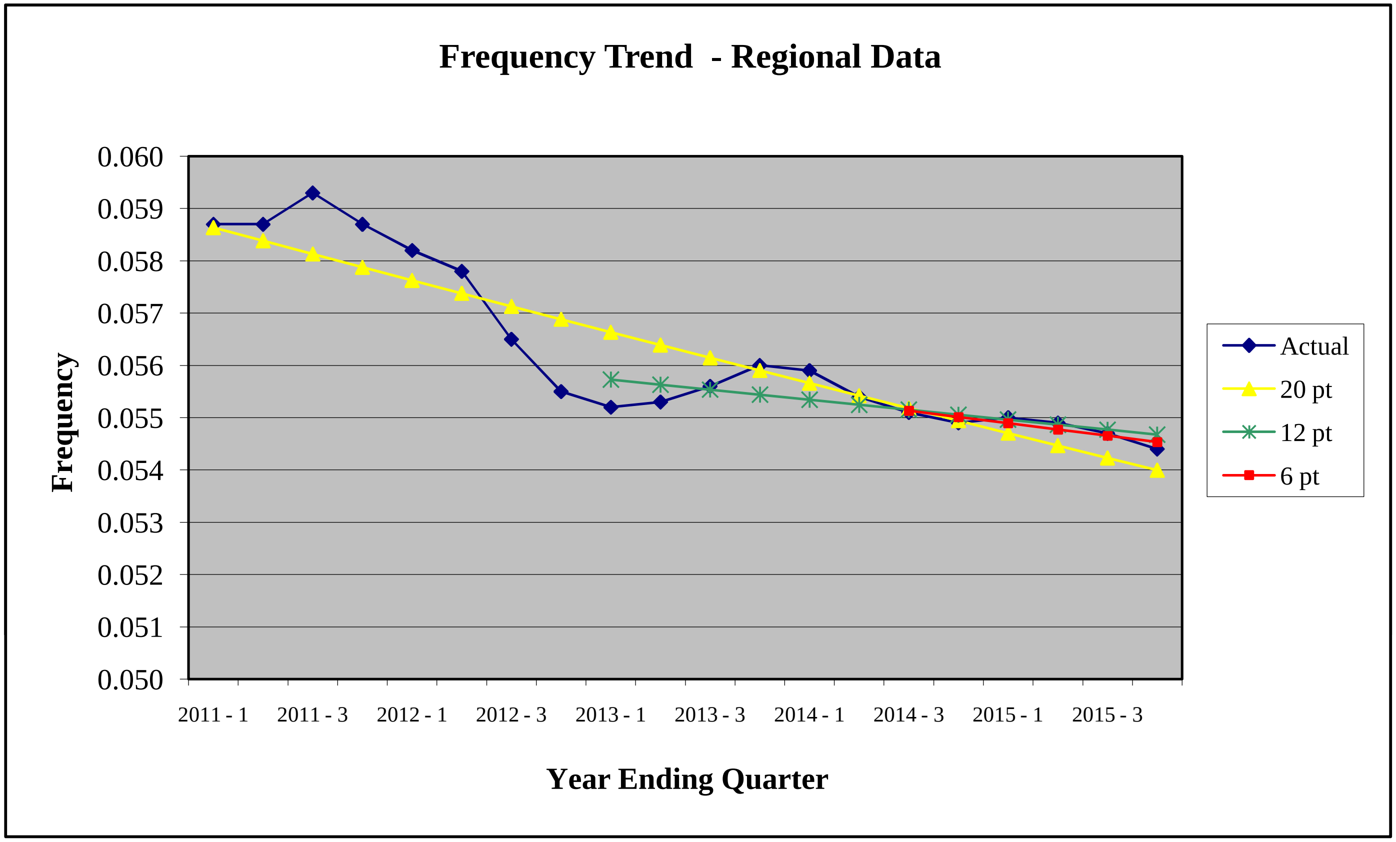
State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
Loss Trend Selections - Regional Data

Year Ending Quarter - X	(1) Earned Exposure	(2) Closed Claim Count	(3) Paid Losses	(4) Frequency	(5) Severity	(6) Pure Premium
2011 - 1	131,911	7,745	$8,220,899	0.0587	$1,061.45	$62.32
2011 - 2	132,700	7,785	$8,381,016	0.0587	$1,076.56	$63.16
2011 - 3	133,602	7,917	$8,594,389	0.0593	$1,085.56	$64.33
2011 - 4	135,079	7,928	$8,705,108	0.0587	$1,098.02	$64.44
2012 - 1	137,384	7,997	$8,816,379	0.0582	$1,102.46	$64.17
2012 - 2	138,983	8,037	$8,901,163	0.0578	$1,107.52	$64.04
2012 - 3	140,396	7,939	$8,873,491	0.0565	$1,117.71	$63.20
2012 - 4	140,997	7,831	$8,799,730	0.0555	$1,123.70	$62.41
2013 - 1	140,378	7,748	$8,736,859	0.0552	$1,127.63	$62.24
2013 - 2	139,682	7,719	$8,676,220	0.0553	$1,124.01	$62.11
2013 - 3	138,982	7,730	$8,629,925	0.0556	$1,116.42	$62.09
2013 - 4	138,984	7,790	$8,642,835	0.0560	$1,109.48	$62.19
2014 - 1	139,155	7,782	$8,602,105	0.0559	$1,105.38	$61.82
2014 - 2	139,618	7,741	$8,535,327	0.0554	$1,102.61	$61.13
2014 - 3	139,996	7,720	$8,466,272	0.0551	$1,096.67	$60.48
2014 - 4	140,141	7,691	$8,412,159	0.0549	$1,093.77	$60.03
2015 - 1	140,754	7,735	$8,513,679	0.0550	$1,100.67	$60.49
2015 - 2	141,534	7,769	$8,614,224	0.0549	$1,108.79	$60.86
2015 - 3	141,800	7,755	$8,702,135	0.0547	$1,122.13	$61.37
2015 - 4	142,986	7,778	$8,761,588	0.0544	$1,126.46	$61.28

Exponential Trend	Frequency	Severity	Pure Premium
20 pt	-1.7%	0.5%	-1.2%
16 pt	-1.3%	-0.1%	-1.4%
12 pt	-0.7%	-0.2%	-0.9%
8 pt	-1.2%	1.2%	-0.1%
6 pt	-0.9%	2.5%	1.6%
4 pt	-1.5%	3.3%	1.9%
Selections			
Current	-1.0%	0.5%	-0.5%
Projected	-1.0%	1.5%	0.5%

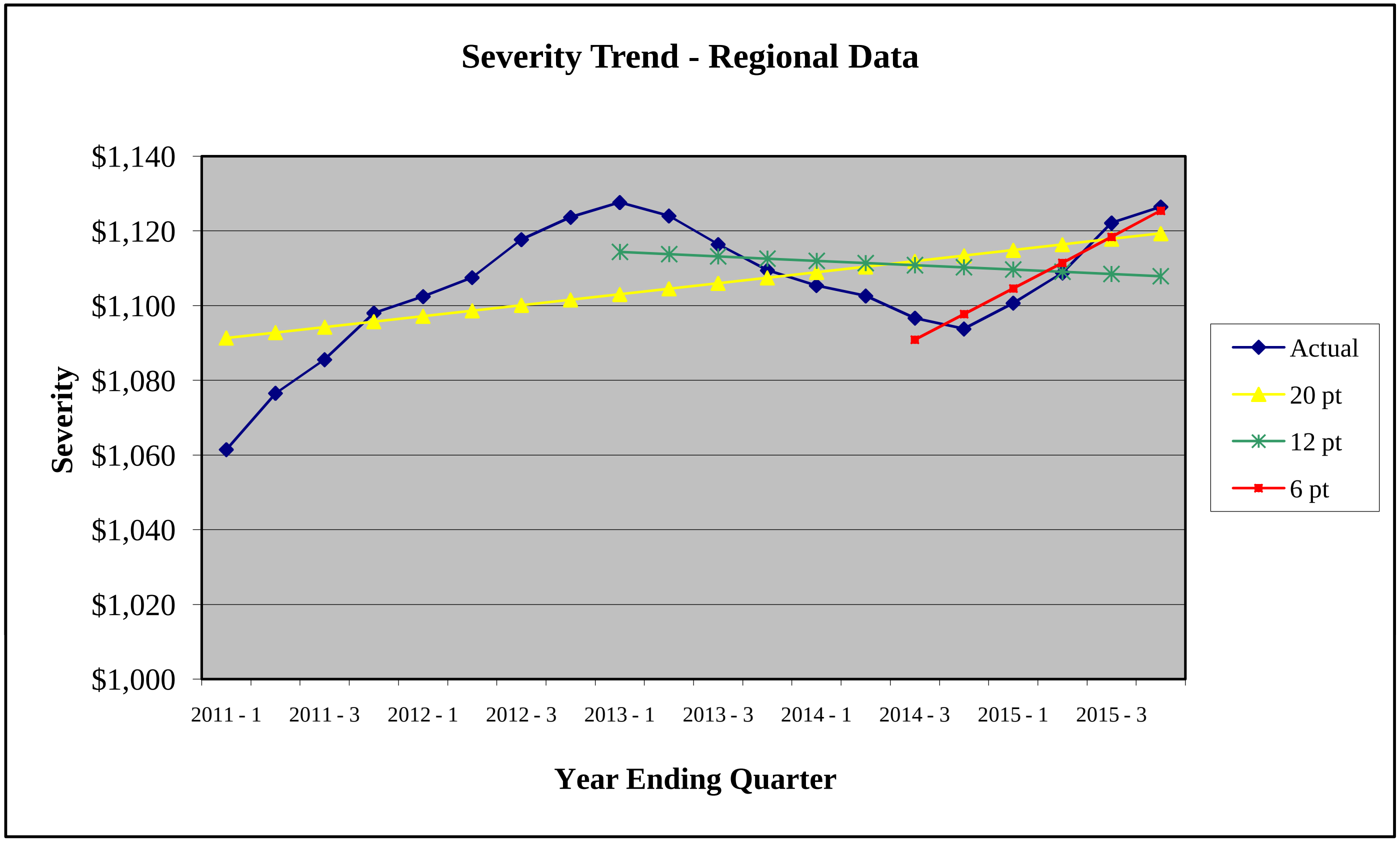
(1) Shown on a 4-Quarter Rolling Total Basis
(2) Shown on a 4-Quarter Rolling Total Basis
(3) Shown on a 4-Quarter Rolling Total Basis
(4) = (2) / (1)
(5) = (3) / (2)
(6) = (3) / (1)

State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
Frequency Trend - Regional Data



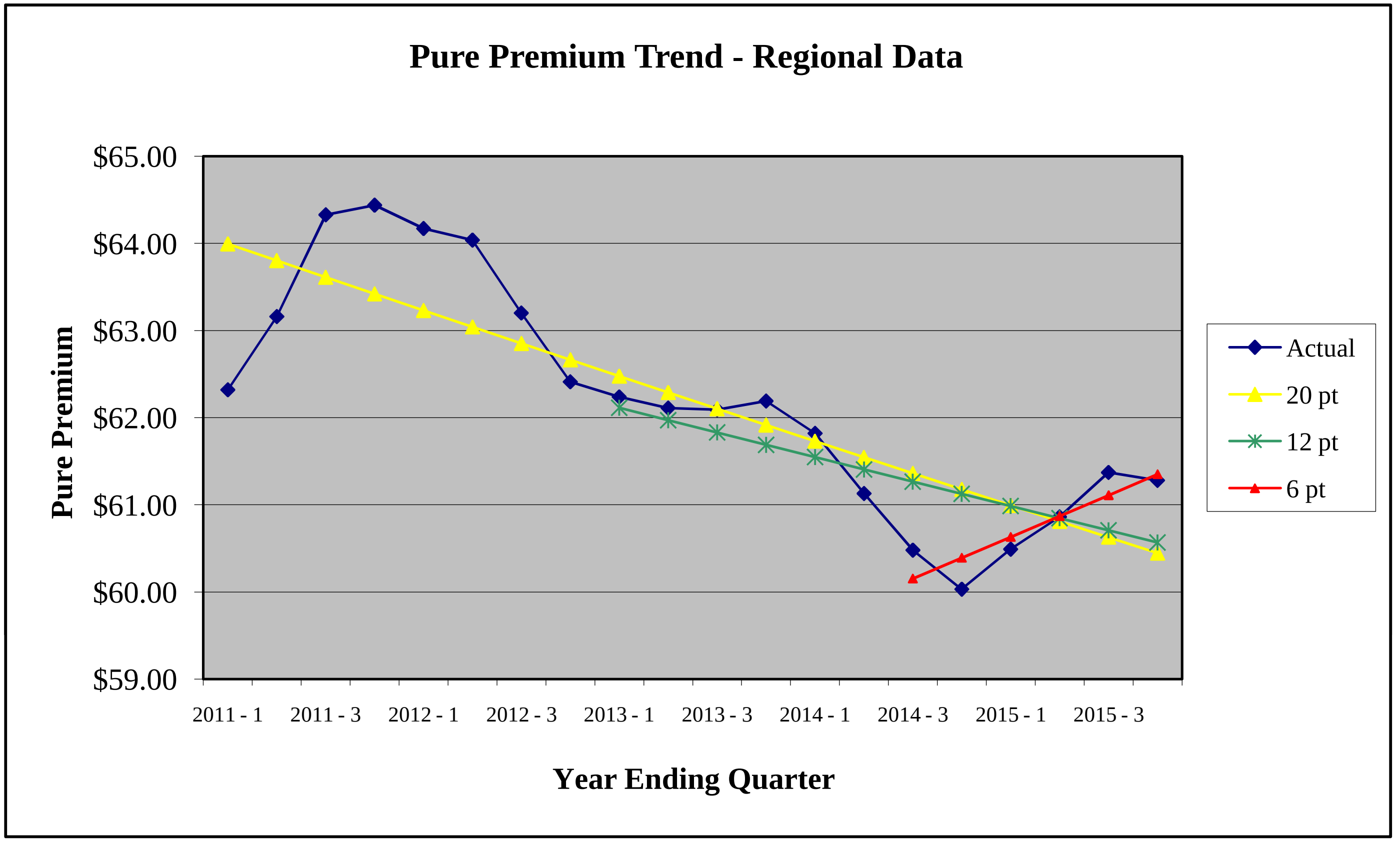
Exponential Trend			Selections	
20 pt	-1.7%		Current	-1.0%
12 pt	-0.7%		Projected	-1.0%
6 pt	-0.9%			

State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
Severity Trend -Regional Data



Exponential Trend			Selections	
20 pt	0.5%		Current	0.5%
12 pt	-0.2%		Projected	1.5%
6 pt	2.5%			

State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
Pure Premium Trend - Regional Data



Exponential Trend			Selections*	
20 pt	-1.2%		Current	-0.5%
12 pt	-0.9%		Projected	0.5%
6 pt	1.6%		* Calculated Using Frequency and Severity Trend Selections	

State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
Loss Trend

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Accident Year	Selected Current Trend	Current Cost Trend Period	Current Trend Factor	Selected Projected Trend	Projected Cost Trend Period	Projected Trend Factor	Loss Trend Factor
2011	-0.5%	4.00	0.9801	0.5%	2.25	1.0113	0.9912
2012	-0.5%	3.00	0.9851	0.5%	2.25	1.0113	0.9962
2013	-0.5%	2.00	0.9900	0.5%	2.25	1.0113	1.0012
2014	-0.5%	1.00	0.9950	0.5%	2.25	1.0113	1.0062
2015	-0.5%	0.00	1.0000	0.5%	2.25	1.0113	1.0113

(1) From Loss Trend Exhibit - 1
(2) From 07/01/20XX to 06/30/2015
(3) = [1.0 + (1)] ^ (2)
(4) From Loss Trend Exhibit - 1
(5) From 07/01/2015 to 09/30/2017
(6) = [1.0 + (4)] ^ (5)
(7) = (3) x (6)

State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
ULAE Ratio

Calendar Year	(1) Countrywide Paid Losses and ALAE	(2) Countrywide Paid ULAE	(3) ULAE Ratio
2013	$ 283,299,252	$ 41,170,520	14.5%
2014	$ 290,213,410	$ 41,262,210	14.2%
2015	$ 293,934,810	$ 41,959,671	14.3%
Total	$ 867,447,472	$ 124,392,401	14.3%

(4) Selected Ratio	14.3%
(5) ULAE Factor	1.143

(3) = (2) / (1)
(5) = 1.0 + (4)

State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
Expense Calculation

	2013	2014	2015	3-Year Weighted Average	Selected
(1) General Expenses					
a Countrywide Expenses	$ 29,143,368	$ 29,940,978	$ 30,763,160		
b Countrywide Earned Premium	$ 466,001,205	$ 478,971,842	$ 491,904,082		
c Ratio[(a)/(b)]	6.3%	6.3%	6.3%	6.3%	6.3%
d % Assumed Fixed					75.0%
e Fixed Expense % [(c)x(d)]					4.7%
f Variable Expense % [(c)x(1.0-(d))]					1.6%
(2) Other Acquisition					
a Countrywide Expenses	$ 40,158,296	$ 40,912,479	$ 41,652,543		
b Countrywide Written Premium	$ 468,850,020	$ 482,345,783	$ 495,356,701		
c Ratio[(a)/(b)]	8.6%	8.5%	8.4%	8.5%	8.5%
d % Assumed Fixed					75.0%
e Fixed Expense % [(c)x(d)]					6.4%
f Variable Expense % [(c)x(1.0-(d))]					2.1%
(3) Licenses and Fees					
a State Expenses	$ 3,124	$ 3,190	$ 3,229		
b State Written Premium	$ 1,289,484	$ 1,380,129	$ 1,407,811		
c Ratio[(a)/(b)]	0.2%	0.2%	0.2%	0.2%	0.2%
d % Assumed Fixed					100.0%
e Fixed Expense % [(c)x(d)]					0.2%
f Variable Expense % [(c)x(1.0-(d))]					0.0%
(4) Commission and Brokerage					
a State Expenses	$ 145,073	$ 154,235	$ 158,712		
b State Written Premium	$ 1,289,484	$ 1,380,129	$ 1,407,811		
c Ratio[(a)/(b)]	11.3%	11.2%	11.3%	11.2%	11.2%
d % Assumed Fixed					0.0%
e Fixed Expense % [(c)x(d)]					0.0%
f Variable Expense % [(c)x(1.0-(d))]					11.2%
(5) Taxes					
a State Expenses	$ 27,338	$ 27,549	$ 29,853		
b State Written Premium	$ 1,289,484	$ 1,380,129	$ 1,407,811		
c Ratio[(a)/(b)]	2.1%	2.0%	2.1%	2.1%	2.1%
d % Assumed Fixed					0.0%
e Fixed Expense % [(c)x(d)]					0.0%
f Variable Expense % [(c)x(1.0-(d))]					2.1%
(6) Fixed Expense Provision	(1e) + (2e) + (3e) + (4e) + (5e)				11.3%
(7) Variable Expense Provision	(1f) + (2f) + (3f) + (4f) + (5f)				17.0%

APPENDIX B: HOMEOWNERS INDICATION

Companies use a variety of approaches to produce homeowners overall rate level indications. The following exhibits show an example of a homeowners rate level indication using the pure premium approach. All policies are annual, and the proposed effective date for new rates in State XX is January 1, 2017. Rates are expected to be in effect for one year.

The individual exhibits are as follows:

- PP Indication: summarizes the calculation of the overall indicated rate per exposure using the pure premium method on five accident years of experience evaluated as of March 31, 2016.
- Non-Modeled Cat: details the calculation of the catastrophe provision for non-modeled catastrophes.
- AIY Projection: supports the selection of the projected average amount of insurance years (AIY) in the effective period, as used in the derivation of the non-modeled catastrophe pure premium.
- Reinsurance: derives the projected net reinsurance cost per exposure.
- Loss Development: displays the derivation and selection of the loss and ALAE development factors using the chain ladder method.
- Loss Trend: supports the selection of the loss trend factors based on the historical changes of pure premium.
- ULAE Ratio: shows the determination of the ULAE factor based on the historical relationship of paid ULAE to paid losses and ALAE.
- Expense: derives the fixed and variable expense provisions using the exposure-based projection method.

PP (PURE PREMIUM) INDICATION EXHIBIT

The overall rate level indication is calculated on the Pure Premium Indication Exhibit based on the latest five accident years evaluated as of March 31, 2016. The projected non-catastrophe pure premium for State XX is credibility-weighted with a regional non-catastrophe pure premium, and then added to the sum of the non-modeled catastrophe pure premium and modeled catastrophe pure premium. The total projected pure premium is combined with the projected fixed expense per exposure and the projected net reinsurance cost per exposure. This value is compared to the variable permissible loss ratio to obtain the overall indicated rate. Each column or input of the exhibit is described in detail below. Some inputs are derived on later exhibits, as noted in the exhibit footnotes.

Column 1 is the earned exposure by calendar year. Columns 2 through 7 show the calculation of the projected non-catastrophe pure premium (including LAE). The projected non-catastrophe loss and LAE in Column 6 is calculated by multiplying the non-catastrophe reported loss and paid ALAE (Column 2) by the loss development factor (Column 3), the loss trend factor (Column 4), and the ULAE factor (Column 5). The projected non-catastrophe pure premium in Column 7 is Column 6 divided by the earned exposures in Column 1. Row 8 is the selected non-catastrophe pure premium, which is based on the five-year weighted average non-catastrophe pure premium.

Rows 9 through 13 show the derivation of the credibility-weighted non-catastrophe pure premium. The full credibility standard of 1,082 claims is based on the classical credibility approach; partial credibility is calculated using the square root rule. The complement of credibility is the regional non-catastrophe pure premium.

Rows 14 and 15 display the non-modeled catastrophe pure premium and the modeled catastrophe pure premium, respectively. Row 16 is the total projected pure premium, calculated as the sum of Rows 13, 14, and 15.

Row 17 shows the projected net reinsurance cost per exposure.

The indicated rate per exposure (Row 22) is calculated as the sum of the total pure premium (Row 16), the projected fixed expense per exposure (Row 18), and the projected net reinsurance cost per exposure (Row 17), divided by the variable permissible loss ratio (Row 21).

NON-MODELED CAT EXHIBIT

This exhibit outlines the calculation of the non-modeled catastrophe pure premium, considering a twenty year period. Column 1 shows the amount of insurance years, or AIY, (in $000s) for each calendar year. Amount of insurance years represents the sum total of amount of insurance for all policies in-force during the calendar year. If the non-modeled catastrophe pure premium was based on the ratio of non-modeled catastrophe losses and ALAE to house years, the ratio would increase over time due to the influence of inflation and other factors on the numerator during the twenty year period. Using AIY in the denominator is a simple way to adjust the ratio for inflation. Column 2 displays the non-modeled catastrophe losses and ALAE for each calendar year. Column 3 is the ratio of Column 2 to Column 1, called the Cat-to-AIY Ratio. Row 4 is the arithmetic average of the Cat-to-AIY Ratios. Row 6 is the non-modeled catastrophe provision per $1,000 of AIY, or the average Cat-to-AIY Ratio adjusted by the ULAE factor in Row 5 (calculated in a subsequent exhibit). The non-modeled catastrophe provision per $1,000 of AIY is multiplied by the selected average amount of insurance for the period the rates are to be in effect (Row 7, as calculated in the AIY Projection Exhibit). The resulting non-modeled catastrophe pure premium is displayed in Row 8.

AIY PROJECTION EXHIBIT

The projected average AIY is used to calculate the expected non-modeled catastrophe pure premium. The AIY Projection Exhibit details how the projected average AIY is calculated.

Columns 1 through 3 list the amount of insurance years (in $000s), earned exposures, and the ratio of the two. The annual change in the AIY-to-earned exposure ratio is shown in Column 4. Column 5 is the result of an exponential curve fit to the AIY-to-earned exposure ratios, and projected through the year 2018. Row 6 displays the average AIY for the effective period (Policy Year 2017), or the arithmetic average of Column 5 for 2017 and 2018. Row 7 shows the selected projected average AIY.

REINSURANCE EXHIBIT

A reinsurance contract was purchased with an effective date of January 1, 2017 and a twelve-month term. The Reinsurance Exhibit calculates the net reinsurance cost per exposure, which considers both the expected reinsurance recoveries and the cost of the reinsurance contract.

Row 1 displays the expected reinsurance recoveries associated with the reinsurance contract. This is the output of catastrophe models and is the expected recoveries in an "average year." Row 2 shows the cost of reinsurance, or the expected premium that will be ceded to the reinsurer. The net cost of reinsurance is calculated in Row 3 as Row 2 minus Row 1.

Rows 4 through 7 derive the projected exposures for the effective period of the reinsurance contract. Row 4 contains the latest year's exposures. Row 5 displays an estimate of annual exposure growth based on company goals. The projection period in Row 6 is the length of time between the midpoint of the latest year and the midpoint of the reinsurance contract term. Row 7 shows the projected exposures, which is the product of the latest year exposures and the expected exposure increase, raised to the power of the length of the projection period.

The projected net reinsurance cost per exposure is shown in Row 8, and is the net cost of reinsurance divided by the projected exposures.

LOSS DEVELOPMENT EXHIBIT

This is the same procedure used for the personal automobile example in Appendix A. Thus, the same comments apply.

LOSS TREND EXHIBIT

This is the same procedure used for the personal automobile example, except that the data is at the pure premium level rather than at the frequency and severity level. Thus, the same comments apply.

ULAE RATIO EXHIBIT

This is the same procedure used for the personal automobile example. Thus, the same comments apply.

EXPENSE EXHIBIT

The underwriting expense provisions are determined using the exposure-based projection method. This assumes the historical relationships between variable expenses and premium and between fixed expenses and exposures are expected to continue during the projected period.

Sheet 1

On Sheet 1, the expenses are divided into the following categories: general expense; other acquisition; taxes, licenses, and fees; and commissions and brokerage. The calculations and selections are performed for each category independently.

For each of the expense categories, Row "a" shows the expense associated with each category for each of the three calendar years. The expense is either at the state or countrywide level, depending on the category. Row "b" contains the percentage of the expense assumed to be fixed. Rows "c" through "e" show the derivation of the fixed expense per exposure for each expense category. Row "c" displays the fixed expenses for each year, which is calculated by multiplying the expenses for the category by the selected percentage from Row "b." Row "d" displays the exposure per year; the exposures are state or countrywide and written or earned depending on the expense category. Row "e" includes the average fixed expense per exposure for each of the three years.

Rows "f" through "h" show the derivation of the variable expense ratio for each expense category. Row "f" displays the variable expenses for each year, which are calculated by multiplying the total expenses for the category by one minus the selected fixed percentage from Row "b." Row "g" displays the premium for each year; the premium is state or countrywide and written or earned depending on the expense category. Row "h" includes the variable expense ratio (i.e., the variable expense divided by the premium) for each of the three years, the average of the three years combined, and the selected variable expense ratio. The selected expense ratio was chosen as the most recent year's ratio to be responsive to trends.

Row 5 at the bottom of the exhibit is the total of the fixed expense per exposure across all of the categories for each of the three years. Rows 6 through 9 describe the projection of the fixed expenses. Row 6 displays the selected expense trend from Sheet 2. Row 7 is the length of the trend period for each year, which is measured as the number of years from the average written date of each calendar year to the average written date for the time period the rates are to be in effect. Row 8 contains the projected fixed expense trend factor for each year. Row 9 is the projected average fixed expense per exposure that results from the application of the trend factor. The selected projected average fixed expense per exposure is based on the latest year's projection. This figure is used directly in the pure premium indication formula. Row 10 is the total of the selected variable expense provisions; this is used directly in the indication formula.

Sheet 2

Sheet 2 outlines the procedure for selecting the fixed expense trend. Rows 1 and 3 display the annualized changes over the latest two years in the Employment Cost Index and Consumer Price Index, respectively. These two changes are weighted together based on the portion of the major expense categories assumed to be related to salaries. Row 4 displays the selected expense trend.

State XX
Wicked Good Insurance Company
Homeowners
Pure Premium Indication

Calendar Accident Year	(1) Earned Exposures	(2) Non-Cat Reported Losses and Paid ALAE	(3) Loss Development Factor	(4) Loss Trend Factor	(5) ULAE Factor	(6) Projected Ultimate Non-Cat Losses and LAE	(7) Projected Non-Cat Pure Premium
2011	12,760	$ 5,161,624	1.0000	1.1939	1.012	$6,236,412	$488.75
2012	12,766	$ 4,820,968	1.0012	1.1705	1.012	$5,717,511	$447.87
2013	12,805	$ 4,112,172	1.0055	1.1476	1.012	$4,802,025	$375.01
2014	12,834	$ 5,052,052	1.0186	1.1251	1.012	$5,859,265	$456.54
2015	13,411	$ 6,559,224	1.0555	1.1030	1.012	$7,727,993	$576.24
Total	64,576	$ 25,706,040				$30,343,206	$469.88

(8)	Selected Projected Non-Cat Pure Premium	$469.88
(9)	Number of Claims	683
(10)	Claims Required for Full Crediblity	1,082
(11)	Credibilty	79.5%
(12)	Regional Non-Cat Pure Premium	$585.75
(13)	Credibility-Weighted Non-Cat Pure Premium	$493.63
(14)	Non-Modeled Cat Pure Premium	$29.11
(15)	Modeled Cat Pure Premium	$74.57
(16)	Total Pure Premium	$597.31
(17)	Projected Net Reinsurance Cost Per Exposure	$15.68
(18)	Projected Fixed Expense Per Exposure	$77.83
(19)	Variable Expense Provision	13.8%
(20)	Profit and Contingency Provision	5.0%
(21)	Variable Permissible Loss Ratio	81.2%
(22)	Indicated Rate	$850.76
(23)	Selected Rate	$850.76

(2) Reported Losses and Paid ALAE Evaluated As Of 03/31/2016
(3) From Loss Development Exhibit
(4) From Loss Trend Exhibit - 1
(5) From ULAE Ratio Exhibit
(6) = (2) x (3) x (4) x (5)
(7) = (6) / (1)
(11) = Min{ [(9) / (10)] ^ 0.5, 1.0 }
(13) = (8) x (11) + (12) x [1.0 - (11)]
(14) From Non-Modeled Cat Exhibit
(15) From Hurricane Catastrophe Model
(16) = (13) + (14) + (15)
(17) From Cost of Reinsurance Exhibit
(18) From Expense Exhibit - 1
(19) From Expense Exhibit - 1
(21) = 100% - (19) - (20)
(22) = [(16) + (17) + (18)] / (21)

State XX
Wicked Good Insurance Company
Homeowners
Calculation of Non-Modeled Cat Loading

Calendar Year	(1) Amount of Insurance Years ($000s)	(2) Reported Cat Losses and Paid ALAE	(3) Cat-to-AIY Ratio
1996	$ 1,752,020	$ 4,412	0.003
1997	$ 1,911,500	$ 26,236	0.014
1998	$ 2,110,710	$ 155,872	0.074
1999	$ 2,333,580	$ 38,689	0.017
2000	$ 2,494,580	$ 145,490	0.058
2001	$ 2,545,420	$ 227,118	0.089
2002	$ 2,631,470	$ 222,464	0.085
2003	$ 2,738,710	$ 833,316	0.304
2004	$ 2,858,230	$ 173,649	0.061
2005	$ 2,927,850	$ 2,668,809	0.912
2006	$ 2,936,440	$ 96,981	0.033
2007	$ 2,923,330	$ 256,753	0.088
2008	$ 2,910,500	$ 54,333	0.019
2009	$ 2,944,090	$ 475,524	0.162
2010	$ 2,916,440	$ 1,230	-
2011	$ 2,665,300	$ 70,299	0.026
2012	$ 2,771,912	$ 485,029	0.175
2013	$ 2,882,788	$ 29,025	0.010
2014	$ 2,998,100	$ 69,868	0.023
2015	$ 3,208,151	$ 178,200	0.056

(4) All-Year Arithmetic Average	0.110
(5) ULAE Factor	1.012
(6) Non-Modeled Cat Provision Per AIY	0.111
(7) Selected Average AIY Per Exposure	$ 262.21
(8) Non-Modeled Cat Pure Premium	$ 29.11

(3) = (2) / (1)
(4) = Average of (3)
(5) From ULAE Ratio Exhibit
(6) = (4) x (5)
(7) From AIY Projection Exhibit
(8) = (6) x (7)

State XX
Wicked Good Insurance Company
Homeowners
Calculation of Projected Average AIY

	(1)	(2)	(3)	(4)	(5)
Calendar Year	Amount of Insurance Years ($000s)	Earned Exposures	AIY-to-Earned Exposure Ratio	Annual Change	AIY-to-Earned Exposure Exponential Fit
2011	$ 2,665,300	12,760	$ 208.88		$ 209.58
2012	$ 2,771,912	12,766	$ 217.13	3.9%	$ 216.93
2013	$ 2,882,788	12,805	$ 225.13	3.7%	$ 224.53
2014	$ 2,998,100	12,834	$ 233.61	3.8%	$ 232.39
2015	$ 3,208,151	13,411	$ 239.22	2.4%	$ 240.54
2016					$ 248.97
2017					$ 257.69
2018					$ 266.72

(6) Projected Average AIY in Effective Period	$ 262.21
(7) Selected AIY in Effective Period	$ 262.21

(3) = (1) / (2)
(4) = Current Year (3) / Prior Year (3) - 1.0
(5) Exponential Fit of (3) Using Data From Calendar Years 2011 Through 2015
(6) Average of (5) For Latest 2 Years

State XX
Wicked Good Insurance Company
Homeowners
Cost of Reinsurance

(1) Expected Reinsurance Recoveries	$	458,673
(2) Cost of Reinsurance (Expected Ceded Premium)	$	673,248
(3) Net Cost of Reinsurance	$	214,575
(4) Latest Year Exposures		13,411
(5) Expected Annual Exposure Increase		1.0%
(6) Projection Period		2.0
(7) Projected Exposures		13,681
(8) Projected Net Reinsurance Cost Per Exposure	$	15.68

(3) = (2) - (1)
(4) From Pure Premium Indication Exhibit
(5) Based on Company Goals
(6) From Midpoint of Latest Year to Midpoint of Reinsurance Contract
[(07/01/2015) to (07/01/2017)]
(7) = (4) x [1.00 + (5)] ^ (6)
(8) = (3) / (7)

State XX
Wicked Good Insurance Company
Homeowners
Loss Development - Countrywide Data

	Reported Losses and Paid ALAE Evaluated as of						
Accident Year	15 Months	27 Months	39 Months	51 Months	63 Months	75 Months	85 Months
2009	45,407,811	47,542,171	47,840,609	47,944,098	48,357,583	48,352,642	48,350,368
2010	42,964,965	44,624,511	45,673,824	45,959,994	45,908,833	45,939,203	
2011	33,313,292	34,495,215	35,097,059	35,141,818	35,182,407		
2012	30,176,335	31,335,306	31,658,815	31,908,268			
2013	30,613,176	31,102,898	31,455,116				
2014	30,932,080	31,923,956					
2015	34,377,105						

Age-to-Age Factors	15-27	27-39	39-51	51-63	63-75	75 to Ult
2009	1.0470	1.0063	1.0022	1.0086	0.9999	1.0000
2010	1.0386	1.0235	1.0063	0.9989	1.0007	
2011	1.0355	1.0174	1.0013	1.0012		
2012	1.0384	1.0103	1.0079			
2013	1.0160	1.0113				
2014	1.0321					
(1) All-Year Average	1.0346	1.0138	1.0044	1.0029		
(2) 3-Year Average	1.0288	1.0130	1.0052	1.0029		
(3) 4-Year Average	1.0305	1.0156	1.0044			
(4) Average Excluding Hi-Lo	1.0362	1.0130	1.0043	1.0012		
(5) Geometric Average	1.0346	1.0137	1.0044	1.0029		
(6) Selected Age-to-Age	1.0362	1.0130	1.0043	1.0012	1.0000	
(7) Age-to-Ultimate	1.0555	1.0186	1.0055	1.0012	1.0000	

(1) Straight Average
(2) Straight Average
(3) Straight Average
(4) Straight Average Excluding Highest and Lowest Values
(5) = (Product of Age-to-Age Factors) ^ (1.0 / Number of Age-to-Age Factors)
(7) = Cumulative Product of (6)

State XX
Wicked Good Insurance Company
Homeowners
Loss Trend Selections - Regional Data

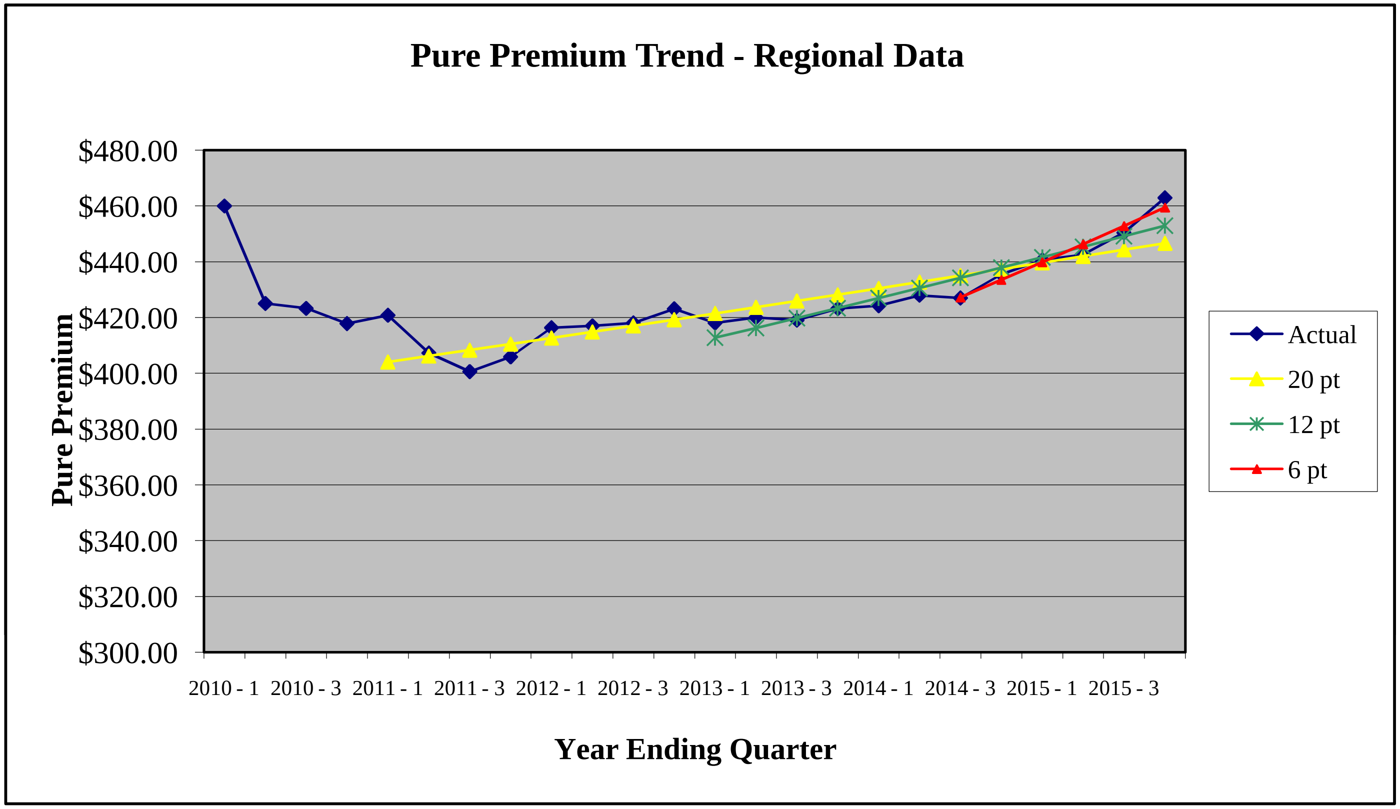
Year Ending Quarter - X	Paid Pure Premium (including ALAE)	Annual Change
2010 - 1	$460.03	
2010 - 2	$425.04	
2010 - 3	$423.31	
2010 - 4	$417.86	
2011 - 1	$420.80	-8.5%
2011 - 2	$407.29	-4.2%
2011 - 3	$400.62	-5.4%
2011 - 4	$405.91	-2.9%
2012 - 1	$416.38	-1.1%
2012 - 2	$417.09	2.4%
2012 - 3	$418.06	4.4%
2012 - 4	$423.13	4.2%
2013 - 1	$418.06	0.4%
2013 - 2	$420.06	0.7%
2013 - 3	$419.06	0.2%
2013 - 4	$423.26	0.0%
2014 - 1	$424.31	1.5%
2014 - 2	$428.01	1.9%
2014 - 3	$427.06	1.9%
2014 - 4	$435.57	2.9%
2015 - 1	$440.73	3.9%
2015 - 2	$442.49	3.4%
2015 - 3	$450.44	5.5%
2015 - 4	$462.98	6.3%

Exponential Trend	Pure Premium
24 pt	1.0%
20 pt	2.1%
16 pt	2.4%
12 pt	3.4%
8 pt	4.8%
6 pt	6.0%
4 pt	6.8%

Selections

Current	2.0%
Projected	4.0%

State XX
Wicked Good Insurance Company
Homeowners
Pure Premium Trend - Regional Data



Exponential Trend	
20 pt	2.1%
12 pt	3.4%
6 pt	6.0%

Selections	
Current	2.0%
Prospective	4.0%

State XX
Wicked Good Insurance Company
Homeowners
Loss Trend

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Accident Year	Selected Current Trend	Current Cost Trend Period	Current Trend Factor	Selected Projected Trend	Projected Cost Trend Period	Projected Trend Factor	Loss Trend Factor
2011	2.0%	4.00	1.0824	4.0%	2.5	1.1030	1.1939
2012	2.0%	3.00	1.0612	4.0%	2.5	1.1030	1.1705
2013	2.0%	2.00	1.0404	4.0%	2.5	1.1030	1.1476
2014	2.0%	1.00	1.0200	4.0%	2.5	1.1030	1.1251
2015	2.0%	0.00	1.0000	4.0%	2.5	1.1030	1.1030

(1) From Loss Trend Exhibit - 1
(2) From 07/01/20XX to 07/01/2015
(3) = [1.0 + (1)] ^ (2)
(4) From Loss Trend Exhibit - 1
(5) From 07/01/2015 to 01/01/2018
(6) = [1.0 + (4)] ^ (5)
(7) = (3) x (6)

State XX
Wicked Good Insurance Company
Homeowners
ULAE Ratio

Calendar Year	(1) Countrywide Paid Loss and ALAE	(2) Countrywide Paid ULAE	(3) ULAE Ratio
2013	$ 30,985,798	$ 334,665	1.1%
2014	$ 30,903,249	$ 238,788	0.8%
2015	$ 34,683,131	$ 567,247	1.6%
Total	$ 96,572,178	$ 1,140,700	1.2%
		(4) Selected Ratio	1.2%
		(5) ULAE Factor	1.012

(3) = (2) / (1)
(5) = 1.0 + (4)

State XX
Wicked Good Insurance Company
Homeowners
Expense Calculation

	2013	2014	2015	3-Year Average	Selected
(1) General					
a Countrywide Expenses	$2,238,241	$2,301,402	$2,432,343		
b % Assumed Fixed					75.0%
c Fixed Expense $ [(a)x(b)]	$1,678,681	$1,726,052	$1,824,257		
d Countrywide Earned Exposures	56,884	57,452	58,027		
e Fixed Expense Per Exposure [(c)/(d)]	$29.51	$30.04	$31.44	$30.33	
f Variable Expense $ [(a)x(1.0-(b))]	$559,560	$575,351	$608,086		
g Countrywide Earned Premium	$51,764,213	$53,143,516	$53,965,296		
h Variable Expense % [(f)/(g)]	1.1%	1.1%	1.1%	1.1%	1.1%
(2) Other Acquisition					
a Countrywide Expenses	$2,582,786	$2,715,731	$2,912,054		
b % Assumed Fixed					75.0%
c Fixed Expense $ [(a)x(b)]	$1,937,090	$2,036,798	$2,184,041		
d Countrywide Written Exposures	56,602	57,740	58,317		
e Fixed Expense Per Exposure [(c)/(d)]	$34.22	$35.28	$37.45	$35.65	
f Variable Expense $ [(a)x(1.0-(b))]	$645,697	$678,933	$728,014		
g Countrywide Written Premium	51,907,954	53,554,406	55,235,122		
h Variable Expense % [(f)/(g)]	1.2%	1.3%	1.3%	1.3%	1.3%
(3) Taxes, Licenses and Fees					
a State Expenses	$200,879	$205,363	$210,002		
b % Assumed Fixed					25.0%
c Fixed Expense $ [(a)x(b)]	$50,220	$51,341	$52,501		
d State Written Exposures	12,820	13,123	13,478		
e Fixed Expense Per Exposure [(c)/(d)]	$3.92	$3.91	$3.90	$3.91	
f Variable Expense $ [(a)x(1.0-(b))]	$150,659	$154,022	$157,502		
g State Written Premium	$11,217,062	$11,810,250	$12,332,420		
h Variable Expense % [(f)/(g)]	1.3%	1.3%	1.3%	1.3%	1.3%
(4) Commission and Brokerage					
a State Expenses	$1,115,970	$1,207,693	$1,244,644		
b % Assumed Fixed					0.0%
c Fixed Expense $ [(a)x(b)]	$0	$0	$0		
d State Written Exposures	12,820	13,123	13,478		
e Fixed Expense Per Exposure [(c)/(d)]	$0.00	$0.00	$0.00	$0.00	
f Variable Expense $ [(a)x(1.0-(b))]	$1,115,970	$1,207,693	$1,244,644		
g State Written Premium	$11,217,062	$11,810,250	$12,332,420		
h Variable Expense % [(f)/(g)]	9.9%	10.2%	10.1%	10.1%	10.1%
(5) Total Fixed Expense Per Exposure (1e+2e+3e+4e)	$67.65	$69.23	$72.79	$69.89	
(6) Fixed Expense Trend (from Expense Exhibit - 2)					3.4%
(7) Trend Period (from 07/01/xxxx to 07/01/2017)	4.00	3.00	2.00		
(8) Fixed Expense Trend Factor [1.0 + (6)] ^ (7)	1.1431	1.1055	1.0692		
(9) Projected Fixed Expenses	$77.33	$76.53	$77.83	$77.23	$77.83
(10) Variable Expense Provision [(1h) + (2h) + (3h) + (4h)]					13.8%

State XX
Wicked Good Insurance Company
Homeowners
Calculation of Annual Expense Trend

(1) Employment Cost Index - Finance, Insurance & Real Estate, excluding Sales Occupations - (annual change over latest 2 years) U.S. Department of Labor	4.8%
(2) % of Other Acquisition and General Expense used for Salaries and Employee Relations & Welfare - Insurance Expense Exhibit, 2015	50.0%
(3) Consumer Price Index, All Items - (annual change over latest 2 years)	1.9%
(4) Annual Expense Trend - [(1) x (2)] + [(3) x {100% - (2) }]	3.4%
Selected Annual Expense Trend	3.4%

APPENDIX C: MEDICAL MALPRACTICE INDICATION

The following exhibits show an example of an overall rate level indication for a medical malpractice insurance program using the loss ratio indication approach. Medical malpractice insurance can be written on an occurrence or claims-made basis; the data used in this example is based on occurrence policies. Due to the long-tailed nature of medical malpractice insurance and the higher frequency of large losses, the data is more volatile and ratemaking techniques are slightly different than those used for personal automobile and homeowners.

All policies are annual and the proposed effective date of the rate change in State XX is May 1, 2016. Rates are expected to be in effect for one year.

The individual exhibits are as follows:

- LR Indication: summarizes the calculation of the overall indicated rate change using the loss ratio methodology based on five years of State XX calendar-accident year experience evaluated as of September 30, 2015.
- Current Rate Level: details the calculation of the current rate level factors using the parallelogram method.
- Loss Development: displays the derivation of the selected ultimate loss and ALAE using a combination of the chain ladder and Bornhuetter-Ferguson methods.
- Net Trend: supports the selection of the net trend factors based on historical changes of frequency, severity, and premium.
- Expense and ULAE Ratio: derives the expense (including ULAE) provision using the all variable projection method.

LR (LOSS RATIO) INDICATION EXHIBIT

The overall rate level indication is calculated on the LR (Loss Ratio) Indication Exhibit. The five-year projected ultimate loss and ALAE ratio is calculated and compared to the permissible loss ratio to obtain the statewide indicated rate change. This statewide rate indication is then credibility-weighted with the countrywide rate indication. Each column of the exhibit is described in detail below. Some inputs are calculated on later exhibits.

Columns 1 through 3 show the calculation of earned premium at current rate level. Column 1 displays the earned premium for each of the five calendar-accident years. Column 2 displays the current rate level adjustment factors used to convert the historical premium to current rate level. Column 3 is the earned premium at current rate level, which is calculated as the product of Columns 1 and 2.

Column 4 shows the ultimate losses and ALAE selected for each accident year. Normally, companies cap losses at the basic limit to minimize the impact of extraordinary losses on the rate level indication; in this case, basic limits losses were not available and total limit losses were used. Column 5 shows the selected net trend factor, which is multiplied by Column 4 to obtain the projected ultimate loss and ALAE in Column 6. These projected ultimate loss and ALAE are then divided by the premium at current rate level in Column 3 to obtain Column 7. The selected loss and ALAE ratio in Row 8 is the five-year weighted projected loss and ALAE ratio.

The permissible loss ratio is derived in Rows 9 through 11. Chapter 7 defined the permissible loss ratio as one minus the underwriting expense provision minus the target underwriting profit provision (all as a percent of premium). In this example, ULAE is measured as a percent of premium so it is considered with the variable underwriting expenses rather than the loss and ALAE. Row 9 is the underwriting expense and ULAE ratio, and Row 10 shows the target underwriting profit provision. Note that the underwriting profit provision is negative. Recall that the insurer's total profit is underwriting profit plus investment income. Since the investment income is expected to be high in this long-tailed line of business, the underwriting profit can actually be negative. The underwriting expense and ULAE ratio and the underwriting profit provision are subtracted from one to obtain the permissible loss ratio shown in Row 11. The statewide rate indication, as shown in Row 12, is calculated by comparing the selected projected loss and ALAE ratio (Row 8) to the permissible loss ratio (Row 11).

Rows 13 through 15 show the calculation of the credibility measure. Row 13 shows the number of reported claims for the five most recent accident years as of September 30, 2015. The standard for full credibility is listed in Row 14 and was determined using the classical credibility approach and assuming no variation in claims costs. The number of claims for full credibility, 683, is derived such that there is a 95% probability that the observed experience will be within 7.5% of the expected experience. Row 15, the credibility measure, is calculated using the square root rule.

The countrywide indication is displayed in Row 16. Row 17 shows the credibility-weighted rate indication of the statewide and countrywide results. A rate change is then selected in Row 18.

CURRENT RATE LEVEL EXHIBIT

These two sheets use the same parallelogram method that was used to adjust earned premium to current rate level in the personal automobile rating example. Sheet 1 shows the derivation of the cumulative rate level indices for each rate level group during or after the historical period. Sheet 2 calculates the current rate level factors.

LOSS DEVELOPMENT EXHIBIT

Since the reported losses and ALAE in the historical data are not fully mature, they need to be developed to ultimate. The Loss Development Exhibit shows the calculation of ultimate loss and ALAE using three loss development techniques. In long-tailed lines of business it is common to use multiple loss development methods when deriving ultimate losses. The results of the three techniques are then used to judgmentally select ultimate loss & ALAE by accident year. The exhibit is described in detail below.

Sheets 1-3

Sheets 1 and 2 show the calculation and selection of age-to-ultimate loss development factors using the chain ladder approach. Sheet 1 is the chain ladder approach applied to paid losses and paid ALAE. Sheet 2 is based on reported losses and paid ALAE. The losses in these exhibits are total limit losses; if capped losses had been available, the loss development analysis would have been conducted on that basis as well.

Sheet 3 shows the calculation of claim count development factors using the chain ladder approach on historical reported claim counts.[55] The resulting ultimate claim counts are used in the derivation of the net loss ratio trend discussed later.

Sheets 4-5

Since medical malpractice is a long-tailed line of business with relatively more large losses than other lines of business, the link ratio patterns are less stable. This is especially true for the more recent evaluation points; consequently, the reported Bornhuetter-Ferguson method (Sheets 4 and 5) is used to develop losses and ALAE to ultimate for the three most recent accident years. In this example, an average expected loss and ALAE ratio is calculated based on older years (2010-2011) and projected to the rate level and cost level of each of the three most recent years (2012, 2013, and 2014). This ratio is multiplied by earned premium to derive expected losses and ALAE for each of the three years. The age-to-ultimate factors from the reported chain ladder method are used to calculate the portion of these losses that are unreported as of September 30, 2015. These estimated unreported losses are added to the actual reported losses as of the same valuation date to derive the ultimate losses and ALAE for each year.

Sheet 4 shows the calculation of the two-year (2010-2011) average ultimate loss and ALAE ratio forecasted to the rate level and cost level of 2011. Column 1 contains earned premium for 2010 and 2011. Column 2 contains ultimate loss and ALAE for 2010 and 2011, which is the straight average of the ultimate loss and ALAE from the reported and paid chain ladder methods. Column 3 is a ratio of Column 2 to Column 1. This two-year average ratio is then adjusted to the average rate level and cost level of 2011. Column 4 is the adjustment to the 2011 average rate level; it is calculated as the ratio of the 2011 average rate level to the average rate level of each respective year. Column 5 is the selected net trend for application in the Bornhuetter-Ferguson method. It is based on an examination of the trend in severity and adjusted frequency from 2005-2011 (which is outlined in the Net Trend – 1 exhibit). As ultimate losses have not yet been derived for the most recent years, this trend analysis (for the purpose of applying the Bornhuetter-Ferguson method) does not consider the most recent years. Column 6 is the trend length, or the number of years from the midpoint of each accident year (July 1, 20xx) until the midpoint of Accident Year 2011 (July 1, 2011). The net trend adjustment in Column 7 is the sum of one plus the selected net trend, raised to the power of the trend length. Column 8 is the ultimate loss and ALAE ratio as of 2011, or the product of Column 3 and Column 7, divided by Column 4.

Sheet 5 shows the calculation of the ultimate loss and ALAE ratio for Accident Years 2012-2014, using the Bornhuetter-Ferguson method. Column 1 contains the two-year average ultimate loss and ALAE ratio calculated in Sheet 4. Columns 2 through 5 derive the adjustment to convert the two-year average loss ratio, which is at the 2011 rate level, to the rate level of each of the respective accident years. The adjustment in Column 5 is the ratio of the average rate level for each accident year in Column 3 to the 2011 rate level in Column 4. Columns 6 through 8 derive the adjustment to forecast the average reported losses from the 2011 cost level to the cost level of each respective accident year. Column 6 shows the same selected net trend as used in Sheet 4. Column 7 displays the net trend length from the midpoint of Accident Year 2011 (July 1, 2011) to the midpoint of each respective year (July 1, 20XX). Column 8 is the sum of 1.00 plus the selected net trend, raised to the power of the trend length. Column 9 is the expected loss and ALAE ratio for each respective year, calculated as the product of Columns 1 and 8,

[55] The developed claims are required for the trend procedure and the calculation of credibility.

divided by Column 5. Column 10 multiplies the expected loss and ALAE ratio by the earned premium in Column 2.

Column 11 shows the reported age-to-ultimate factors derived from the chain ladder method. Column 12 calculates the percent of losses unreported as one minus the reciprocal of Column 11. Column 13 shows the reported losses and ALAE as of September 30, 2015. Column 14 derives the expected losses and ALAE not yet reported as of September 30, 2015, as the product of Column 10 and 12. Column 15, the ultimate losses and ALAE from the Bornhuetter-Ferguson method, is the sum of the reported losses and ALAE (Column 13) and the expected losses and ALAE not yet reported (Column 14) as of September 30, 2015.

Sheet 6

Sheet 6 shows the derivation of the selected ultimate loss and ALAE for each accident year in consideration of the chain ladder and Bornhuetter-Ferguson results. Columns 1 through 6 show the calculation of the indicated ultimate losses using paid development factors and reported development factors from the chain ladder method. Columns 1 and 2 show paid loss and paid ALAE, and reported loss and paid ALAE, respectively. Columns 3 and 4 show the paid and reported chain ladder loss development factors, respectively. Columns 5 and 6 display the ultimate loss and ALAE derived using the paid and reported loss development methods, respectively. Column 7 shows the Bornhuetter-Ferguson ultimate loss and ALAE for the three most recent accident years.

Columns 5 through 7 are used to select ultimate loss and ALAE by accident year. A straight average of the paid and reported chain ladder results are used for Accident Years 2005 through 2011. Because of the volatility in the more recent years, an average of the reported chain ladder and Bornhuetter-Ferguson results is used for Accident Years 2012 and 2013, and the Bornhuetter-Ferguson result is used for Accident Year 2014. In all accident years, an additional criterion is applied to the selected ultimate loss and ALAE: each year’s selected ultimate loss and ALAE must be equal to or greater than that year’s reported losses and paid ALAE as of September 30, 2015.

NET TREND EXHIBIT

Because the proposed rates will be in effect in a future policy period, the historical loss ratios need to be adjusted to account for expected trends between the two periods. In the personal automobile example, the premium trend and loss trend components are analyzed and selected separately. In this example, premium trend is considered within the loss trend. The adjusted frequency trend is based on historical patterns of the ratio of ultimate claim counts to earned premium at current rate level; therefore, changes in this ratio represent the net effect of changes in frequency and average premium. The severity trend is based on the historical pattern of ultimate loss and ALAE divided by ultimate claim counts (both derived using the chain ladder method). The selected net trend is based on the combination of the severity trend and the adjusted frequency trend.

It is important to note that due to the long-tailed nature of medical malpractice, loss trends are typically based on losses and claim counts developed to ultimate rather than paid losses and reported claim counts (as is common practice in short-tailed lines). This may seem to present a conundrum in this example since losses need to be developed to ultimate before measuring trend, but Bornhuetter-Ferguson requires losses to be trended before projecting to ultimate. In this example, the Bornhuetter-Ferguson method is used to developed losses to ultimate only for the three most recent accident years (2012-2014). The net trend factor is applied to the two-year (2010-2011) average ultimate loss and ALAE. The net trend, therefore, is based on data through 2011 only, and the loss and ALAE are brought to ultimate using the chain ladder method. Sheet 1 outlines the trend analysis conducted for the Bornhuetter-Ferguson method, and Sheet 2 outlines the trend analysis for the LR indication. The only difference between these sheets is the time period considered, and the resulting trend selection.

Sheet 1

On Sheet 1, the severity and adjusted frequency trends are analyzed separately for Accident Years 2005-2011. Exponential trends are fit to the data, and trend selections are made based on the results.

Columns 1 through 5 show the calculation of the severity by accident year. Column 1 displays the selected ultimate loss and ALAE based on the chain ladder analyses. Column 2 displays the reported claim counts. These claim counts are developed using the reported age-to-ultimate factors shown in Column 3 to obtain the ultimate claim counts shown in Column 4. The severity listed in Column 5 is calculated by dividing the selected ultimate loss and ALAE by the developed claim count.

Columns 6 through 9 show the calculation of the adjusted frequency (i.e., ultimate claim count divided by earned premium at current rate level). Column 6 shows the earned premium by accident year. This premium is adjusted to current rate level using the current rate level factors shown in Column 7. The resulting earned premium at current rate level is shown in Column 8. The adjusted frequency shown in Column 9 is calculated by dividing the ultimate claim count (Column 4) by the earned premium at current rate level (Column 8) and multiplying by 1 million (for ease of viewing the values). By dividing developed claim counts by premium instead of exposures, the adjusted frequency is implicitly reflecting frequency and premium trends within one measure.

Rows 10 and 11 display exponential trends fit to the severity and adjusted frequency data. Selected trends are shown in Rows 12 and 13. These selections are made in consideration of the exponential trends and judgment with respect to the volatility of the data. The selected severity and adjusted frequency trends are combined to form the net trend, as shown in Row 14.

Sheet 2

Sheet 2 follows the same format as Sheet 1 except that the most recent accident years (2012-2014) are considered in the trend data. Exponential trends are fit to 2005-2014 as well as 2010-2014. The selected net trend, in Row 16 relies more heavily on the recent period.

Sheet 3

Sheet 3 shows the calculation of each accident year's net trend factors for use in the LR Indication. Column 1 displays the net trend selection for each accident year from Sheet 2. Column 2 shows the trend period for each accident year, which is the number of years between the midpoint of the historical period (July 1, 20XX) and the average expected loss date for when the rates will be in effect (May 1, 2017). The total net trend factor for each accident year (Column 3) is calculated by taking the sum of one and the selected net trend and raising it to the power of the trend period.

EXPENSE AND ULAE RATIO EXHIBIT

The rates charged must include a provision for expenses. Unlike the personal automobile and homeowners examples, all underwriting expenses are treated as variable expense, and ULAE are also measured as a percent of premium. Due to the volatility of this line of business, the ratios for all categories of expense are calculated using countrywide data.

Sheet 1

Sheet 1 shows the derivation of the selected ULAE ratio. Column 1 shows the countrywide earned premium for each of the last five calendar years. Column 2 shows the paid unallocated loss adjustment expense (ULAE) for the same years. Column 3 is the ratio of Column 2 to Column 1. The selected ULAE ratio is based on the five-year ratio in Column 3. While it is more intuitive to study the relationship between ULAE and losses, ULAE are a relatively small portion of the total expenses in this example so comparing ULAE to earned premium is acceptable.

Sheet 2

Sheet 2 calculates an expense ratio for each category of expense (general expenses; other acquisition expenses; taxes, licenses, and fees; and commission and brokerage) using the three most recent calendar years of countrywide data. For each expense category, Row “a” displays the expenses paid for that calendar year and Row “b” displays the premium. Earned premium is used to calculate the expense ratio for general expenses since these expenses are incurred throughout the life of the policy. All other expense ratios use written premium since these expenses are assumed to be incurred at policy inception (when written). All expenses are assumed to be variable (i.e., they vary by amount of premium). The historical variable expense ratios (Row “c”) are calculated by dividing Row “a” by Row “b.” The three-year ratio is displayed though the ratios from the latest year are selected due to the downward trend exhibited.

The UW expense ratio is calculated in Row 5 by summing the selected ratios for the four categories of expenses listed in Rows 1 through 4. The selected ULAE Ratio is shown on Sheet 1. Row 7 is the total expense ratio, which is the sum of the UW expense ratio (Row 5) and the ULAE ratio (Row 6). This figure is not trended, which implicitly assumes that expenses and premium will increase/decrease at the same rate.

State XX
Wicked Good Insurance Company
Medical Malpractice
Indicated Rate Change

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Calendar-Accident Year	Earned Premium	Current Rate Level Factor	Earned Premium @ CRL	Ultimate Loss and ALAE	Net Trend Factor	Projected Ultimate Loss and ALAE	Projected Ultimate Loss and ALAE Ratio
2010	$ 14,904,664	1.2029	$ 17,928,820	$ 11,673,500	1.7902	$ 20,897,900	116.6%
2011	$ 14,494,543	1.2058	$ 17,477,520	$ 11,200,835	1.6439	$ 18,413,053	105.4%
2012	$ 14,442,449	1.2724	$ 18,376,572	$ 6,290,368	1.5095	$ 9,495,310	51.7%
2013	$ 14,834,605	1.3018	$ 19,311,689	$ 18,254,793	1.3862	$ 25,304,794	131.0%
2014	$ 18,265,093	1.2391	$ 22,632,277	$ 23,371,444	1.2729	$ 29,749,511	131.4%
Total	$ 76,941,354		$ 95,726,878	$ 70,790,940		$ 103,860,568	108.5%

(8)	Selected Loss and ALAE Ratio	108.5%
(9)	Expense and ULAE Ratio	34.7%
(10)	Profit and Contingency Provision	-5.0%
(11)	Permissible Loss Ratio	70.3%
(12)	Statewide Indicated Rate Change	54.3%
(13)	Number of Reported Claims	283
(14)	Claims Required for Full Credility Standard	683
(15)	Credibility	64.4%
(16)	Countrywide Indicated Rate Change	18.5%
(17)	Credibility-Weighted Indicated Rate Change	41.6%
(18)	Selected Rate Change	41.6%

(1) From Net Trend Exhibit - 2
(2) From Current Rate Level Exhibit - 2
(3) = (1) x (2)
(4) From Loss Development Exhibit - 6
(5) From Net Trend Exhibit - 3
(6) = (4) x (5)
(7) = (6) / (3)
(9) From Expense & ULAE Ratio Exhibit - 2
(11) = 100% - (9) - (10)
(12) = [(8) / (11)] - 1.0
(13) Derived from Net Trend Exhibit - 2
(15) = Min{ [(13) / (14)] ^ 0.5, 1.0 }
(17) = (12) x (15) + (16) x [1.0 - (15)]

State XX
Wicked Good Insurance Company
Medical Malpractice
Rate Change History

	(1)	(2)	(3)	(4)
Rate Level Group	Effective Date	Rate Change	Rate Level Index	Cumulative Rate Level Index
A			1.0000	1.0000
B	10/01/11	-7.6%	0.9240	0.9240
C	03/01/14	14.6%	1.1460	1.0589
D	07/01/15	13.6%	1.1360	1.2029

(3) = 1.0 + (2)
(4) = Cumulative Product of (3)

State XX
Wicked Good Insurance Company
Medical Malpractice
Calculation of Current Rate Level Factors

	(1a) Portion of Earned Premium Assumed in Each Rate Level Group				(2)	(3)	(4)
Calendar Year	A	B	C	D	Average Rate Level Index	Current Rate Level Index	CRL Factor
2005	100.000%	0.000%	0.000%	0.000%	1.0000	1.2029	1.2029
2006	100.000%	0.000%	0.000%	0.000%	1.0000	1.2029	1.2029
2007	100.000%	0.000%	0.000%	0.000%	1.0000	1.2029	1.2029
2008	100.000%	0.000%	0.000%	0.000%	1.0000	1.2029	1.2029
2009	100.000%	0.000%	0.000%	0.000%	1.0000	1.2029	1.2029
2010	100.000%	0.000%	0.000%	0.000%	1.0000	1.2029	1.2029
2011	96.875%	3.125%	0.000%	0.000%	0.9976	1.2029	1.2058
2012	28.125%	71.875%	0.000%	0.000%	0.9454	1.2029	1.2724
2013	0.000%	100.000%	0.000%	0.000%	0.9240	1.2029	1.3018
2014	0.000%	65.278%	34.722%	0.000%	0.9708	1.2029	1.2391
2015	0.000%	1.389%	86.111%	12.500%	1.0750	1.2029	1.1190
(1b) Cumulative Rate Level	1.0000	0.9240	1.0589	1.2029			

(1a) Portion of Each Calendar Year's Earned Premium by Rate Level Group
(1b) Cumulative Rate Level for Each Rate Level Group
(2) = (1b) Weighted by (1a) Within Each Calendar Year
(4) = (3) / (2)

State XX
Wicked Good Insurance Company
Medical Malpractice
Paid Loss Development

	Paid Losses & Paid ALAE Evaluated As Of									
Accident Year	21 Months	33 Months	45 Months	57 Months	69 Months	81 Months	93 Months	105 Months	117 Months	129 Months
2005	$151,700	$318,200	$2,227,400	$4,029,300	$5,727,600	$5,735,000	$5,735,000	$5,735,000	$5,735,000	$5,735,000
2006	$7,400	$48,100	$255,300	$543,900	$906,500	$2,608,500	$2,701,000	$2,701,000	$2,701,000	
2007	$66,600	$255,300	$1,172,900	$3,670,400	$4,014,500	$4,092,200	$4,539,900	$4,591,700		
2008	$18,500	$288,600	$1,594,700	$4,902,500	$7,721,900	$8,269,500	$8,524,800			
2009	$96,200	$358,900	$1,243,200	$6,327,000	$6,878,300	$7,377,800				
2010	$25,900	$666,000	$1,191,400	$3,799,900	$7,770,000					
2011	$11,100	$74,000	$366,300	$7,895,800						
2012	$40,700	$436,900	$1,029,200							
2013	$22,200	$170,200								
2014	$873,200									

Age-to-Age Factors	21-33	33-45	45-57	57-69	69-81	81-93	93-105	105-117	117-129	129 to Ult
2005	2.0976	7.0000	1.8090	1.4215	1.0013	1.0000	1.0000	1.0000	1.0000	
2006	6.5000	5.3077	2.1304	1.6667	2.8776	1.0355	1.0000	1.0000		
2007	3.8333	4.5942	3.1293	1.0938	1.0194	1.1094	1.0114			
2008	15.6000	5.5256	3.0742	1.5751	1.0709	1.0309				
2009	3.7308	3.4639	5.0893	1.0871	1.0726					
2010	25.7143	1.7889	3.1894	2.0448						
2011	6.6667	4.9500	21.5556							
2012	10.7346	2.3557								
2013	7.6667									
(1) All-Year Average	9.1716	4.3733	5.7110	1.4815	1.4084	1.0440	1.0038	1.0000	1.0000	
(2) 3-Year Average	8.3560	3.0315	9.9448	1.5690	1.0543	1.0586	1.0038	1.0000	1.0000	
(3) 4-Year Average	12.6956	3.1396	8.2271	1.4502	1.5101	1.0440	1.0038	1.0000	1.0000	
(4) Average Excluding Hi-Lo	7.8189	4.3662	3.3225	1.4393	1.0543	1.0332	1.0000			
(5) Weighted Average	5.9419	3.7123	3.8713	1.4188	1.1123	1.0384	1.0040	1.0000	1.0000	
(6) Selected Age-to-Age	5.9419	3.7123	3.8713	1.4188	1.1123	1.0384	1.0040	1.0000	1.0000	1.0000
(7) Age-to-Ultimate	140.5057	23.6466	6.3698	1.6454	1.1597	1.0426	1.0040	1.0000	1.0000	1.0000

(1) Straight Average
(2) Straight Average
(3) Straight Average
(4) Straight Average Excluding Highest and Lowest Values
(5) Average Weighted by Loss
(7) = Cumulative Product of (6)

State XX
Wicked Good Insurance Company
Medical Malpractice
Reported Loss Development

Accident Year	Reported Losses & Paid ALAE Evaluated As Of 21 Months	33 Months	45 Months	57 Months	69 Months	81 Months	93 Months	105 Months	117 Months	129 Months
2005	$336,700	$688,200	$3,892,400	$6,804,300	$5,727,600	$5,735,000	$5,735,000	$5,735,000	$5,735,000	$5,735,000
2006	$62,900	$255,300	$643,800	$876,900	$1,147,000	$2,608,500	$2,701,000	$2,701,000	$2,701,000	
2007	$399,600	$1,032,300	$1,690,900	$4,021,900	$4,366,000	$4,406,700	$4,576,900	$4,739,700		
2008	$640,100	$714,100	$4,092,200	$6,885,700	$8,465,600	$8,473,000	$8,543,300			
2009	$373,700	$1,690,900	$4,972,800	$7,215,000	$7,470,300	$7,414,800				
2010	$118,400	$5,568,500	$7,252,000	$10,848,400	$11,673,500					
2011	$11,100	$140,600	$4,299,400	$8,191,800						
2012	$77,700	$1,158,500	$1,954,200							
2013	$22,200	$3,873,900								
2014	$1,298,700									

Age-to-Age Factors	21-33	33-45	45-57	57-69	69-81	81-93	93-105	105-117	117-129	129 to Ult
2005	2.0440	5.6559	1.7481	0.8418	1.0013	1.0000	1.0000	1.0000	1.0000	
2006	4.0588	2.5217	1.3621	1.3080	2.2742	1.0355	1.0000	1.0000		
2007	2.5833	1.6380	2.3786	1.0856	1.0093	1.0386	1.0356			
2008	1.1156	5.7306	1.6826	1.2294	1.0009	1.0083				
2009	4.5248	2.9409	1.4509	1.0354	0.9926					
2010	47.0313	1.3023	1.4959	1.0761						
2011	12.6667	30.5789	1.9053							
2012	14.9099	1.6868								
2013	174.5000									
(1) All-Year Average	29.2705	6.5069	1.7176	1.0961	1.2557	1.0206	1.0119	1.0000	1.0000	
(2) 3-Year Average	67.3589	11.1893	1.6174	1.1136	1.0009	1.0275	1.0119	1.0000	1.0000	
(3) 4-Year Average	62.2770	9.1272	1.6337	1.1066	1.3193	1.0206	1.0119	1.0000	1.0000	
(4) Average Excluding Hi-Lo	12.5455	3.3623	1.6566	1.1066	1.0038	1.0219	1.0000			
(5) Weighted Average	7.4042	2.5602	1.6706	1.0600	1.0538	1.0157	1.0125	1.0000	1.0000	
(6) Selected Age-to-Age	7.4042	2.5602	1.6706	1.0600	1.0538	1.0157	1.0125	1.0000	1.0000	1.0000
(7) Age-to-Ultimate	36.3768	4.9130	1.9190	1.1487	1.0837	1.0284	1.0125	1.0000	1.0000	1.0000

(1) Straight Average
(2) Straight Average
(3) Straight Average
(4) Straight Average Excluding Highest and Lowest Values
(5) Average Weighted by Loss
(7) = Cumulative Product of (6)

State XX
Wicked Good Insurance Company
Medical Malpractice
Claim Count Development Factors

	Reported Claim Counts Evaluated As Of									
Accident Year	21 Months	33 Months	45 Months	57 Months	69 Months	81 Months	93 Months	105 Months	117 Months	129 Months
2005	33	41	52	59	63	63	63	63	63	63
2006	15	33	48	48	48	48	48	48	48	
2007	26	52	74	85	85	89	93	96		
2008	37	59	70	85	85	85	85			
2009	44	81	85	107	107	107				
2010	19	44	59	67	67					
2011	15	44	63	63						
2012	48	59	67							
2013	33	56								
2014	30									

Age-to-Age Factors	21-33	33-45	45-57	57-69	69-81	81-93	93-105	105-117	117-129	129 to Ult
2005	1.2424	1.2683	1.1346	1.0678	1.0000	1.0000	1.0000	1.0000	1.0000	
2006	2.2000	1.4545	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		
2007	2.0000	1.4231	1.1486	1.0000	1.0471	1.0449	1.0323			
2008	1.5946	1.1864	1.2143	1.0000	1.0000	1.0000				
2009	1.8409	1.0494	1.2588	1.0000	1.0000					
2010	2.3158	1.3409	1.1356	1.0000						
2011	2.9333	1.4318	1.0000							
2012	1.2292	1.1356								
2013	1.6970									
(1) All-Year Average	1.8948	1.2863	1.1274	1.0113	1.0094	1.0112	1.0108	1.0000	1.0000	
(2) 3-Year Average	1.9532	1.3028	1.1315	1.0000	1.0157	1.0150	1.0108	1.0000	1.0000	
(3) 4-Year Average	2.0438	1.2394	1.1522	1.0000	1.0118	1.0112	1.0108	1.0000	1.0000	
(4) Average Excluding Hi-Lo	1.8415	1.2977	1.1266	1.0000	1.0000	1.0000	1.0000			
(5) Weighted Average	1.7370	1.2542	1.1397	1.0089	1.0103	1.0140	1.0147	1.0000	1.0000	
(6) Selected Age-to-Age	1.7370	1.2542	1.1397	1.0089	1.0103	1.0140	1.0147	1.0000	1.0000	1.0000
(7) Age-to-Ultimate	2.6039	1.4991	1.1953	1.0488	1.0395	1.0289	1.0147	1.0000	1.0000	1.0000

(1) Straight Average
(2) Straight Average
(3) Straight Average
(4) Straight Average Excluding Highest and Lowest Values
(5) Average Weighted by Loss
(7) = Cumulative Product of (6)

State XX
Wicked Good Insurance Company
Medical Malpractice
Bornhuetter-Ferguson Developed Losses

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Accident Year	Earned Premium	Ultimate Loss and ALAE	Ultimate Loss and ALAE ratio	Adjustment to Avg Rate Level in 2011	Selected BF Net Trend	Trend Length	Net Trend Adjustment to 2011	Ultimate Loss and ALAE ratio as of 2011
2010	14,904,664	$11,673,500	78.3%	0.9976	13.3%	1.00	1.1330	88.9%
2011	14,494,543	$11,200,835	77.3%	1.0000	13.3%	0.00	1.0000	77.3%
						(9)	2-Year Avg Ultimate Loss and ALAE Ratio (2010-2011)	83.1%

(1) From Net Trend - 1
(2) From Loss Development Exhibit - 6
(3) = (2) / (1)
(4) From (2) in Current Rate Level - 2
(5) from (14) in Net Trend - 1
(6) From 07/01/20XX to 07/01/2011
(7) = [1 + (5)] ^ (6)
(8) = (3) / (4) x (7)
(9) Straight average of (8)

State XX
Wicked Good Insurance Company
Medical Malpractice
Bornhuetter-Ferguson Developed Losses

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Accident Year	2-Year Avg Ultimate Loss and ALAE Ratio (2010-2011)	Earned Premium	Average Rate Level	Rate Level 2011	Average Rate Level Adjustment	Selected BF Net Trend	Trend length from 2011	Net Trend Adjustment	Expected Loss and ALAE Ratio	Expected Losses and ALAE	Reported Age-to-Ult Factor	Percent Unreported	Reported Losses and ALAE a/o 9/30/15	Expected Losses and ALAE Not Yet Reported a/o 9/30/15	B-F Ultimate Losses and ALAE
2012	83.1%	14,442,449	0.9454	0.9976	0.9477	13.3%	1.00	1.133	99.4%	14,355,794	1.9190	47.9%	$1,954,200	$6,876,425	$8,830,625
2013	83.1%	14,834,605	0.9240	0.9976	0.9262	13.3%	2.00	1.284	115.2%	17,089,465	4.9130	79.6%	$3,873,900	$13,603,214	$17,477,114
2014	83.1%	18,265,093	0.9708	0.9976	0.9731	13.3%	3.00	1.454	124.2%	22,685,246	36.3768	97.3%	$1,298,700	$22,072,744	$23,371,444

(1) From Loss Development Exhibit - 4
(2) From Net Trend - 2
(3) From Current Rate Level - 2
(4) From Current Rate Level - 2
(5) = (3) / (4)
(6) From Net Trend - 1
(7) From 07/01/2011 to 07/01/20XX
(8) = [1 + (6)] ^ (7)
(9) = (1) / (5) x (8)
(10) = (2) x (9)
(11) From Loss Development - 2
(12) = 1 - 1 / (11)
(13) From Loss Development - 6
(14) = (10) x (12)
(15) = (13) + (14)

State XX
Wicked Good Insurance Company
Medical Malpractice
Developed Loss Selection

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Accident Year	Paid Losses & ALAE a/o 9/30/15	Reported Losses & Paid ALAE a/o 9/30/15	Paid Age-to-Ultimate Factor	Reported Age-to-Ultimate Factor	Ultimate Losses & ALAE Using Paid Age-to-Ultimate Factors	Ultimate Losses & ALAE Using Reported Age-to-Ultimate Factors	Ultimate Losses Using B-F Method	Selected Loss & ALAE
2005	$ 5,735,000	$ 5,735,000	1.0000	1.0000	$ 5,735,000	$ 5,735,000		$ 5,735,000
2006	$ 2,701,000	$ 2,701,000	1.0000	1.0000	$ 2,701,000	$ 2,701,000		$ 2,701,000
2007	$ 4,591,700	$ 4,739,700	1.0000	1.0000	$ 4,591,700	$ 4,739,700		$ 4,739,700
2008	$ 8,524,800	$ 8,543,300	1.0040	1.0125	$ 8,558,899	$ 8,650,091		$ 8,604,495
2009	$ 7,377,800	$ 7,414,800	1.0426	1.0284	$ 7,692,094	$ 7,625,380		$ 7,658,737
2010	$ 7,770,000	$ 11,673,500	1.1597	1.0837	$ 9,010,869	$ 12,650,572		$ 11,673,500
2011	$ 7,895,800	$ 8,191,800	1.6454	1.1487	$ 12,991,749	$ 9,409,921		$ 11,200,835
2012	$ 1,029,200	$ 1,954,200	6.3698	1.9190	$ 6,555,798	$ 3,750,110	$ 8,830,625	$ 6,290,368
2013	$ 170,200	$ 3,873,900	23.6466	4.9130	$ 4,024,651	$ 19,032,471	$ 17,477,114	$ 18,254,793
2014	$ 873,200	$ 1,298,700	140.5057	36.3768	$ 122,689,577	$ 47,242,550	$ 23,371,444	$ 23,371,444

(1) From Loss Development Exhibit - 1
(2) From Loss Development Exhibit - 2
(3) From Loss Development Exhibit - 1
(4) From Loss Development Exhibit - 2
(5) = (1) x (3)
(6) = (2) x (4)
(7) From Loss Development Exhibit - 5
(8) Judgmentally Selected Based On Combinations of (5), (6), and (7)
2005-2011: max[(2), average of (5) and (6)]
2012-2013 max[(2), average of (6) and (7)]
2014 uses (7) only

State XX
Wicked Good Insurance Company
Medical Malpractice
Net Trend Calculation for Bornhuetter-Ferguson Method

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Accident Year	Selected Ultimate Loss & ALAE	Reported Claim Count	Reported Age-to-Ultimate Factor	Developed Claim Count	Severity	Earned Premium	Current Rate Level Factor	Earned Premium at Current Rate Level	Adjusted Frequency
2005	$ 5,735,000	63	1.0000	63	$ 91,032	$ 17,944,254	1.2029	$ 21,585,143	2.92
2006	$ 2,701,000	48	1.0000	48	$ 56,271	$ 17,942,995	1.2029	$ 21,583,629	2.22
2007	$ 4,739,700	96	1.0000	96	$ 49,372	$ 18,532,758	1.2029	$ 22,293,055	4.31
2008	$ 8,604,495	85	1.0147	86	$ 100,052	$ 18,265,093	1.2029	$ 21,971,080	3.91
2009	$ 7,658,737	107	1.0289	110	$ 69,625	$ 15,590,108	1.2029	$ 18,753,341	5.87
2010	$ 11,673,500	67	1.0395	70	$ 166,764	$ 14,904,664	1.2029	$ 17,928,820	3.90
2011	$ 11,200,835	63	1.0488	66	$ 169,710	$ 14,494,543	1.2058	$ 17,477,520	3.78

		Exponential Trend			Exponential Trend
(10)	2005-2011	17.0%	(11)	2005-2011	8.2%
(12)	Selected Severity Trend for BF	10.0%	(13)	Selected Adjusted Frequency Trend for BF	3.0%
			(14)	Selected Total Net Trend for BF	13.3%

(1) From Loss Development Exhibit - 6
(2) From Loss Development Exhibit - 3
(3) From Loss Development Exhibit - 3
(4) = (2) x (3)
(5) = (1) / (4)
(7) From Current Rate Level Exhibit - 2
(8) = (6) x (7)
(9) = [(4) / (8)] x 1,000,000
(10) Exponential Fit to Severity (2005-2011)
(11) Exponential Fit to Adjusted Frequency (2005-2011)
(12) Forecasted Severity Trend based on (10) and judgment, for use in Bornhuetter Ferguson loss development method
(13) Forecasted Adjusted Frequency Trend based on (11) and judgment, for use in Bornhuetter Ferguson loss development method

State XX
Wicked Good Insurance Company
Medical Malpractice
Net Trend Calculation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Accident Year	Selected Ultimate Loss & ALAE	Reported Claim Count	Reported Age-to-Ultimate Factor	Developed Claim Count	Severity	Earned Premium	Current Rate Level Factor	Earned Premium at Current Rate Level	Adjusted Frequency
2005	$ 5,735,000	63	1.0000	63	$ 91,032	$ 17,944,254	1.2029	$ 21,585,143	2.92
2006	$ 2,701,000	48	1.0000	48	$ 56,271	$ 17,942,995	1.2029	$ 21,583,629	2.22
2007	$ 4,739,700	96	1.0000	96	$ 49,372	$ 18,532,758	1.2029	$ 22,293,055	4.31
2008	$ 8,604,495	85	1.0147	86	$100,052	$ 18,265,093	1.2029	$ 21,971,080	3.91
2009	$ 7,658,737	107	1.0289	110	$ 69,625	$ 15,590,108	1.2029	$ 18,753,341	5.87
2010	$ 11,673,500	67	1.0395	70	$166,764	$ 14,904,664	1.2029	$ 17,928,820	3.90
2011	$ 11,200,835	63	1.0488	66	$169,710	$ 14,494,543	1.2058	$ 17,477,520	3.78
2012	$ 6,290,368	67	1.1953	80	$ 78,630	$ 14,442,449	1.2724	$ 18,376,572	4.35
2013	$ 18,254,793	56	1.4991	84	$217,319	$ 14,834,605	1.3018	$ 19,311,689	4.35
2014	$ 23,371,444	30	2.6039	78	$299,634	$ 18,265,093	1.2391	$ 22,632,277	3.45

		Exponential Trend			Exponential Trend
(10)	2005-2014	16.3%	(11)	2005-2014	3.5%
(12)	2010-2014	15.2%	(13)	2010-2014	-1.0%
(14)	Selected Severity Trend for LR Indication	10.0%	(15)	Selected Adjusted Frequency Trend for LR Indication	-1.0%
			(16)	Selected Total Net Trend for LR indication	8.9%

(1) From Loss Development Exhibit - 6
(2) From Loss Development Exhibit - 3
(3) From Loss Development Exhibit - 3
(4) = (2) x (3)
(5) = (1) / (4)
(7) From Current Rate Level Exhibit - 2
(8) = (6) x (7)
(9) = [(4) / (8)] x 1,000,000
(10) Exponential Fit to Severity (2005-2014)
(11) Exponential Fit to Adjusted Frequency (2005-2014)
(12) Exponential Fit to Severity (2010-2014)
(13) Exponential Fit to Adjusted Frequency (2010-2014)
(14) Forecasted Severity Trend based on (10) and (12) and judgment
(15) Forecasted Adjusted Frequency Trend based on (11) and (13) and judgment
(16) = { [1.0 + (14)] x [1.0 + (15)] } - 1.0; used in LR Indication

State XX
Wicked Good Insurance Company
Medical Malpractice
Net Trend Factors

Accident Year	(1) Selected Net Trend	(2) Trend Period	(3) Net Trend Factor
2010	8.9%	6.83	1.7902
2011	8.9%	5.83	1.6439
2012	8.9%	4.83	1.5095
2013	8.9%	3.83	1.3862
2014	8.9%	2.83	1.2729

(1) From Net Trend Exhibit - 1
(2) From 07/01/20XX to 05/01/2017
(3) = [1.0 + (1)] ^ (2)

State XX
Wicked Good Insurance Company
Medical Malpractice
ULAE Ratio

Calendar Year	(1) Countrywide Earned Premium ($000s)	(2) Countrywide Paid ULAE ($000s)	(3) ULAE Ratio
2010	$ 455,119	$ 16,310	3.6%
2011	$ 724,423	$ 34,010	4.7%
2012	$ 870,129	$ 4,799	0.6%
2013	$ 596,311	$ 10,086	1.7%
2014	$ 548,096	$ 12,573	2.3%
Total	$ 3,194,078	$ 77,778	2.4%

(4) Selected Ratio 2.4%

(3) = (2) / (1)

State XX
Wicked Good Insurance Company
Medical Malpractice
Expense and ULAE Ratio Calculation

	2012	2013	2014	3-Year Average	Selected
(1) General Expenses					
a Countrywide Expenses	$ 67,766	$ 41,658	$ 35,243		
b Countrywide Earned Premium	$ 870,129	$ 596,311	$ 548,096		
c Ratio[(a)/(b)]	7.8%	7.0%	6.4%	7.2%	6.4%
(2) Other Acquisition					
a Countrywide Expenses	$ 29,041	$ 17,853	$ 15,103		
b Countrywide Written Premium	$ 768,631	$ 579,383	$ 576,253		
c Ratio[(a)/(b)]	3.8%	3.1%	2.6%	3.2%	2.6%
(3) Taxes, Licenses, and Fees					
a Countrywide Expenses	$ 21,678	$ 14,800	$ 12,225		
b Countrywide Written Premium	$ 768,631	$ 579,383	$ 576,253		
c Ratio[(a)/(b)]	2.8%	2.6%	2.1%	2.5%	2.1%
(4) Commission and Brokerage					
a Countrywide Expenses	$ 159,751	$ 123,221	$ 122,211		
b Countrywide Written Premium	$ 768,631	$ 579,383	$ 576,253		
c Ratio[(a)/(b)]	20.8%	21.3%	21.2%	21.1%	21.2%

(5) UW Expense Ratio	(1c) + (2c) + (3c) + (4c)	32.3%
(6) ULAE Ratio	From Expense and ULAE Ratio Exhibit - 1	2.4%
(7) UW Expense and ULAE Ratio	(5) + (6)	34.7%

(1b) from Expense and ULAE Ratio - 1
(3b) from (2b)
(4b) from (2b)

APPENDIX D: WORKERS COMPENSATION INDICATION

The following exhibits show an example of an overall rate level indication using the loss ratio approach. This example is based on workers compensation industry data that is used to determine advisory loss costs, including loss adjustment expenses. Individual workers compensation insurers that intend to use these loss costs as a basis for rates must include their own underwriting expense and profit assumptions, as described later in the appendix.

This example uses five accident years of experience evaluated as of December 31, 2016. Since it is industry data, the experience is more stable than that of an individual workers compensation insurer. An individual insurer performing its own rate level indication may wish to use more years of data to increase the stability of the results. The term for these policies is annual, and the proposed effective date for the revised loss costs is July 1, 2017. These loss costs are expected to be relevant for one year.

The exhibits included in this appendix are as follows:

- Premium: calculates the projected loss cost premium.
- Indemnity: derives the indemnity loss ratio for each accident year.
- Medical: derives the medical loss ratio for each accident year.
- LAE: derives the ALAE and ULAE factors.
- Indication: combines the medical and indemnity loss ratios with the ALAE and ULAE ratios to develop an indicated change to the advisory loss costs.
- Company: calculates the adjustment necessary to account for individual company underwriting expenses and profit, as well as deviations to expected losses.

PREMIUM EXHIBIT

This analysis indicates a change to the advisory loss costs, not earned premiums as in Appendices A and C. The denominator of this loss ratio indication is loss cost premium, which is the hypothetical portion of the premium charged by individual companies assuming the current advisory loss costs and historical experience modification factors were used (i.e., it does not reflect any company deviations from the advisory loss costs or any provision for expense and profit). Historical loss cost premium needs to be adjusted to the level expected in the future policy period. This involves adjustments for current rate level, exposure trend, and expected experience modification factors.

Column 1 shows the industry loss cost premium, which has already been adjusted for any subsequent changes in advisory loss costs (i.e., brought to current level) using the extension of exposures technique. Columns 2 through 5 show the calculation of the adjustment to loss cost premium to account for exposure trend. The exposure base for workers compensation insurance is payroll. Since payroll is inflation-sensitive, the premium changes as payroll changes. Column 2 shows the historical changes in payroll by accident year, assuming a constant number of workers. Column 3 converts the annual changes into cumulative factors such that the factor for the most recent accident year period (2016) is indexed to one. Column 4 is the wage increase expected between the most recent historical period and the time the rates are to be in effect. The selected trend of 6.1% is based on an assumed trend of 3.0% for two years (=

(1.03^2) -1.0). Column 5 combines the current and projected future wage changes into a composite exposure trend factor.

Columns 6 and 7 display the historical and expected average experience modification factors. As described in Chapter 15, insurers use experience rating to modify the manual rate for larger risks based on their actual experience. Column 6 shows the average experience modification factor for each historical accident year, and Column 7 shows the experience modification factor expected during the projected period. These factors are determined via a separate study. Loss cost premium in Column 1 is derived using the assumption that historical average experience modification factors were used. Multiplying the historical loss cost premium by the ratio of Column 7 to Column 6 adjusts the loss cost premium to the level of experience modification expected during the projected period. Column 8 combines the exposure trend and experience modification adjustments to calculate the projected loss cost premium.

INDEMNITY EXHIBITS

Sheet 1: Indemnity Loss Development

This sheet displays the reported link ratios by accident year for indemnity losses, starting with the 12-to-24 month link ratios and progressing through to the 336-to-348 month link ratios. The three-year average and the all-year average excluding the highest and lowest link ratio are displayed. The selected link ratios are based on the average excluding the highest and lowest link ratios.

A tail factor was selected based on a separate study; the tail factor represents the development expected beyond 348 months. In this example, the reported losses are expected to reach their ultimate level by 348 months, so the tail factor is set to 1.00. The age-to-ultimate factor at any point is calculated as the product of all subsequent selected link ratios and the tail factor. For example, the 36-to-ultimate factor is the product of all the selected link ratios between and including 36-to-48 months and 336-to-348 months, multiplied by the selected tail factor.

Sheet 2: Indemnity Benefit Cost Level Factors

Indemnity loss costs are impacted by changes in the legislative benefits, changes in utilization of indemnity benefits for each accident year, and general inflationary pressures.

Column 1 displays the estimated average annual impact of changes in the applicable indemnity benefit levels, considering both direct and indirect effects. The Accident Year 2014 effect of -30% is due to a law change, and the impact was calculated in a separate study. The last row includes any known changes in benefits that occur after the experience period.

As indemnity benefits are tied to wage levels, the indemnity benefits change as wages change. Column 2 displays the annual impact of wage inflation on benefits. These figures were calculated in a separate study and reflect the impact of any maximum and minimum benefit level restrictions. The last row for Column 2 is the expected increase in benefits due to wage increases that will occur between the historical period and the projected period; the selection is based on an estimated 1% trend for two years (i.e., from the average loss date of the latest accident year, July 1, 2016, to the average loss date of the policy projection period, July 1, 2018). Note the figures in Column 2 are significantly lower than the factors used to adjust loss cost premium to future wage level (in Sheet 1) due to the impact of maximum benefit level restrictions.

Column 3 is the combined impact of both benefit level changes and wage inflation. Column 4 calculates the factor needed to adjust each historical accident year's reported losses to the projected level.

Sheet 3: Indemnity Loss Ratios

This sheet calculates the expected indemnity loss ratios for each accident year in the experience period. Column 1 is the projected loss cost premium, which is calculated in the Premium Exhibit.

Columns 2 through 5 comprise the calculation of ultimate indemnity losses. Column 2 displays the reported indemnity losses for each accident year in the experience period. Columns 3 and 4 display the loss development and benefit cost level adjustment factors calculated in the prior two sheets. Column 5 is the product of Columns 2 through 4. Column 6 is the ratio of the ultimate projected losses in Column 5 divided by projected premium in Column 1.

MEDICAL EXHIBITS

Sheet 1: Medical Loss Development

This sheet represents the development triangle for the reported medical losses by accident year. This sheet is organized in the same way as described in the Indemnity Loss Development section.

The selected factors are based on the all-year average excluding the highest and lowest factors. Unlike indemnity losses, the reported medical losses in this example are expected to develop beyond 348 months, so a tail factor greater than unity is selected.

Sheet 2: Medical Benefit Cost Level Factors

Legislative and regulatory changes also impact the cost of medical benefits. The fees for many but not all medical services in workers compensation are subject to a fee schedule. Thus, the medical loss costs are impacted by changes in the medical fee schedules as well as changes due to general utilization and inflation.

Column 1 displays the estimated average changes in the applicable medical fee schedule by accident year, considering both direct and indirect effects. The average medical fee based on the schedule decreased in 2014 and subsequently increased in 2016. The medical fee schedule is not expected to change from the most recent period through the projected time period.

Column 2 shows the annual average change in medical benefits not subject to the medical fee schedule. These figures are based on the medical component of the Consumer Price Index (CPI).   The projected "other medical" change is based on an expected annual change of 4% for two years. This considers any expected changes between the most recent period and the projected period.

Column 3 shows the selected percentages of medical losses by accident year assumed to be subject to the fee schedule. These percentages and their complements are used as weights to combine the changes in Column 2 (due to schedule changes) and the changes in Column 3 (changes unrelated to schedule). The result is the combined effect in Column 4. Column 5 converts the changes in Column 4 into the factors needed to adjust historical accident year reported medical losses to the projected loss cost levels.

Sheet 3: Medical Loss Ratios

This sheet calculates the expected medical loss ratios for each accident year in the experience period. The calculations are the same as described in the Indemnity Loss Ratio section.

LAE EXHIBITS

Sheet 1: ALAE Development

This sheet represents the development triangle for paid ALAE by accident year and is organized in the same way as described in the Indemnity Loss Development section.

The selected factors are based on the all-year average excluding the highest and lowest factors. In this example, paid ALAE are expected to develop beyond 348 months, so a tail factor greater than unity is selected.

Sheet 2: ALAE Ratio

This sheet calculates the ratio of ultimate ALAE to ultimate projected losses. ALAE are compared to losses rather than premium in the indication because ALAE are more directly related to the amount of losses than the amount of premium. The sum of the projected ultimate indemnity and medical losses is displayed in Column 1. The ultimate ALAE (Column 4) are the product of the paid ALAE (Column 2) and the ALAE development factor (Column 3). Column 5 is the ratio of the ultimate ALAE to ultimate losses. Row 6 is the selected ALAE ratio, based on the all-year average.

Sheet 3: ULAE Ratio

This exhibit calculates the ULAE ratio based on the historical relationship of calendar year paid ULAE to paid losses. Columns 1 and 2 include the calendar year paid losses (indemnity and medical) and paid ULAE, respectively. Column 3 is the ratio of ULAE to losses by calendar year, and these percentages are the basis of the selection included in Row 4. The selection is based on the latest two years because the actuary expects those years to be more representative of the future.

INDICATION EXHIBIT

This exhibit brings together the results from the previous exhibits and calculates the indicated loss cost premium change. The indemnity and medical expected loss ratios (Columns 1 and 2) are summed and then multiplied by one plus the sum of the ALAE (Column 3) and ULAE (Column 4) ratios to determine the projected loss and LAE ratio for each accident year (Column 5). Row 6 is the selected loss and LAE ratio, which is based on the five-year weighted average.

As the objective of the analysis is to determine the advisory loss costs, the premium does not include any underwriting expenses or profit; therefore, the target loss ratio is 100%. Subtracting one from the selected loss ratio produces the overall indicated change to the current advisory loss cost premium. A separate analysis should be conducted to determine whether the change should be applied uniformly to all risks or whether it should vary by type of risk.

COMPANY EXHIBIT

This exhibit calculates the adjustment an individual company should make to the advisory loss costs to account for underwriting expenses, profit targets, and any operational differences that would affect loss cost levels.

Rows 1 through 4 show the expected underwriting expense as a percentage of total premium for each major expense category. Row 5 is the target profit as a percentage of total premium. Row 6 is the total of the expense and profit percentages. Row 7 is calculated as the reciprocal of one minus the total expense and profit percentages. This adjustment applies multiplicatively to the advisory loss costs to include a provision for underwriting expenses and profit.[56]

Row 8 displays the expected difference in loss costs due to any known operational differences between the individual company and the industry. In this case, an overall average adjustment of -5% was selected to reflect an expectation of lower losses attributable to the company's more stringent underwriting and claims handling practices. The selection is converted into a factor in Row 9.

Row 10 combines the adjustment for expenses and profit with the adjustment for operational differences. This figure represents the deviation factor that the company should apply to the industry advisory loss costs.

Row 11 is the current company deviation factor, and Row 12 is the industry loss cost change. Row 13 combines the change in deviation factors and the loss cost change to calculate the indicated rate change for the company. This assumes that the company's distribution of risks is similar to the industry distribution, and that the industry loss cost change applies uniformly to all risks. If that is not the case, the actual impact for the company may be different from the industry loss cost change.

[56] Equivalently, this adjustment is often expressed as the advisory loss costs divided by one minus the total expense and profit percentages.

Workers Compensation
Calculation of Projected Premium

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Exposure Trend			Historical	Expected	
			Factor to	Expected	Factor to Adjust	Average	Average	
Accident Year	Industry Loss Cost Premium	Annual Payroll Level Change	Current Wage Level	Future Wage Level Change	to Future Wage Level	Experience Modification	Experience Modification	Projected Loss Cost Premium
2012	$ 3,900,972,841	2.5%	1.152	6.1%	1.222	0.991	0.970	$ 4,665,972,903
2013	$ 4,148,612,420	3.0%	1.118	6.1%	1.186	0.985	0.970	$ 4,845,326,599
2014	$ 4,334,300,493	3.7%	1.078	6.1%	1.144	0.981	0.970	$ 4,902,840,541
2015	$ 4,659,789,168	4.2%	1.035	6.1%	1.098	0.982	0.970	$ 5,053,925,714
2016	$ 4,795,461,580	3.5%	1.000	6.1%	1.061	0.957	0.970	$ 5,157,100,516
Total	$ 21,839,136,502							$ 24,625,166,273

(1) Industry loss costs at current rate level (assuming no company deviations and no provision for expense and profit)
(2) Determined in separate study
(3) = [1.0 + (2NextRow)] x (3NextRow)
(4) Based on 3% trend projected for 2 years
(5) = (3) x [1.0 + (4)]
(6) Determined in a separate analysis
(7) Selected
(8) = (1) x (5) x (7) / (6)

Workers Compensation
Reported Indemnity Loss Development

Age-to-Age Development (in months):

Accident Year	12 to 24	24 to 36	36 to 48	48 to 60	60 to 72	72 to 84	84 to 96	96 to 108	108 to 120	120 to 132	132 to 144	144 to 156	156 to 168	168 to 180	180 to 192	192 to 204	204 to 216	216 to 228	228 to 240	240 to 252	252 to 264	264 to 276	276 to 288	288 to 300	300 to 312	312 to 324	324 to 336	336 to 348
1988																				1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1989																			1.002	0.998	1.002	1.001	1.001	1.001	1.001	1.001	1.000	
1990																		1.001	1.001	1.002	1.001	1.002	1.003	1.002	1.001	1.001		
1991																	1.000	1.003	1.000	1.002	1.000	1.002	1.000	1.001	1.000			
1992																1.000	1.001	1.000	1.001	1.001	1.002	1.002	1.001	1.001				
1993															0.999	1.001	1.000	1.001	1.001	1.001	1.000	1.001	1.000					
1994														0.999	1.002	1.000	1.000	1.001	1.001	1.000	1.001	1.001						
1995													0.999	1.001	1.001	1.001	1.000	1.001	1.000	1.000	1.000							
1996												1.001	1.001	1.001	1.000	1.000	1.002	0.999	1.000	1.000								
1997											1.001	1.004	1.001	1.000	1.001	1.000	1.001	1.001	1.000									
1998										1.002	1.003	1.001	1.002	1.001	1.002	1.000	1.003	1.000										
1999									1.002	1.003	1.004	1.003	1.001	1.000	1.001	1.001	1.000											
2000								1.006	1.008	1.004	1.003	1.002	1.001	1.000	1.003	1.000												
2001							1.009	1.007	1.008	1.005	1.003	1.006	1.002	1.002	1.001													
2002						1.016	1.013	1.015	1.006	1.005	1.004	1.001	1.002	1.001														
2003					1.031	1.022	1.020	1.013	1.009	1.007	1.000	1.002	1.002															
2004				1.048	1.038	1.031	1.016	1.017	1.007	0.998	1.003	1.003																
2005			1.092	1.062	1.047	1.030	1.022	1.011	1.003	1.001	1.004																	
2006		1.230	1.109	1.071	1.042	1.026	1.013	1.002	1.007	1.005																		
2007	1.861	1.260	1.117	1.068	1.045	1.021	1.007	1.008	1.003																			
2008	1.910	1.291	1.118	1.068	1.034	1.014	1.011	1.006																				
2009	1.931	1.276	1.123	1.052	1.021	1.015	1.012																					
2010	1.873	1.325	1.106	1.035	1.023	1.021																						
2011	1.952	1.263	1.069	1.033	1.032																							
2012	1.782	1.187	1.069	1.055																								
2013	1.448	1.158	1.087																									
2014	1.503	1.221																										
2015	1.684																											
3-Year Average	1.545	1.189	1.075	1.041	1.025	1.017	1.010	1.005	1.004	1.001	1.002	1.002	1.002	1.001	1.002	1.000	1.001	1.000	1.000	1.000	1.000	1.001	1.000	1.001	1.001	1.001	1.000	1.000
Average xHi Lo	1.792	1.247	1.100	1.055	1.035	1.022	1.013	1.009	1.006	1.004	1.003	1.002	1.001	1.001	1.001	1.000	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001		
Selected	1.792	1.247	1.100	1.055	1.035	1.022	1.013	1.009	1.006	1.004	1.003	1.002	1.001	1.001	1.001	1.000	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.000	1.000
Selected Tail Factor	1.000																											
Cumulative	2.883	1.609	1.290	1.173	1.112	1.074	1.051	1.038	1.028	1.022	1.018	1.015	1.013	1.012	1.011	1.010	1.010	1.009	1.008	1.007	1.006	1.005	1.004	1.003	1.002	1.001	1.000	1.000

Workers Compensation
Indemnity Benefit Cost Level Factors

	(1)	(2)	(3)	(4)
Accident Year	**Benefit Level Change**	**Annual Impact on Benefits due to Wage Inflation**	**Combined Impact on Benefits**	**Factor to Adjust Indemnity Benefits to Projected Cost Level**
2012	0.0%	1.0%	1.0%	0.760
2013	0.0%	2.0%	2.0%	0.745
2014	-30.0%	2.0%	-28.6%	1.044
2015	0.0%	1.5%	1.5%	1.029
2016	0.0%	0.9%	0.9%	1.020
Projected	0.0%	2.0%	2.0%	1.000

(1) Based on average impact of legislative changes
(1Proj) Selected
(2) Based on the weekly wages of injured workers
(2Proj) Selected (1% annual trend)
(3) = [1.0 + (1)] x [1.0 + (2)] - 1.0
(4) = [1.0 + (3NextRow)] x (4NextRow)

Workers Compensation
Loss Ratios-Indemnity Losses Only

	(1)	(2)	(3)	(4)	(5)	(6)
Year	Projected Loss Cost Premium	Reported Indemnity Losses	Indemnity Loss Development Factor	Factor to Adjust Indemnity Benefits to Projected Cost	Projected Ultimate Indemnity Losses	Expected Indemnity Loss Ratio
2012	$ 4,665,972,903	$ 1,678,705,592	1.112	0.760	$ 1,418,707,670	30.4%
2013	$ 4,845,326,599	$ 1,982,528,857	1.173	0.745	$ 1,732,502,230	35.8%
2014	$ 4,902,840,541	$ 1,345,482,170	1.290	1.044	$ 1,812,041,567	37.0%
2015	$ 5,053,925,714	$ 931,871,212	1.609	1.029	$ 1,542,862,823	30.5%
2016	$ 5,157,100,516	$ 668,971,913	2.883	1.020	$ 1,967,218,946	38.1%
Total	$ 24,625,166,273	$ 6,607,559,744			$ 8,473,333,236	34.4%

(1) From Premium Exhibit
(2) Input
(3) From Indemnity Sheet 1 (Development)
(4) From Indemnity Sheet 2 (Cost Change)
(5) = (2) x (3) x (4)
(6) = (5) / (1)

Workers Compensation
Reported Medical Loss Development

Age-to-Age Development (in months):

Accident Year	12 to 24	24 to 36	36 to 48	48 to 60	60 to 72	72 to 84	84 to 96	96 to 108	108 to 120	120 to 132	132 to 144	144 to 156	156 to 168	168 to 180	180 to 192	192 to 204	204 to 216	216 to 228	228 to 240	240 to 252	252 to 264	264 to 276	276 to 288	288 to 300	300 to 312	312 to 324	324 to 336	336 to 348
1988																				1.016	1.011	1.009	1.014	1.010	1.004	1.006	1.007	1.003
1989																			1.015	1.003	1.003	1.020	1.009	1.014	1.003	1.005	1.005	
1990																		1.009	1.008	1.009	1.011	1.003	1.007	1.004	1.006	1.005		
1991																	1.006	1.016	1.012	1.009	1.009	1.009	1.008	1.005	1.015			
1992																1.005	1.005	1.007	1.008	1.009	0.998	1.001	1.005	1.004				
1993															1.004	1.005	1.005	1.006	1.003	1.007	1.002	1.004	1.002					
1994														1.006	1.006	1.003	1.009	1.007	1.008	1.008	1.004	1.000						
1995													1.001	1.004	1.007	1.007	1.009	1.007	1.004	1.001	1.005							
1996												1.005	1.003	1.008	1.007	1.016	1.004	0.998	1.006	1.000								
1997											1.002	1.010	1.006	1.008	1.009	1.005	1.004	1.004	1.002									
1998										1.003	1.009	1.009	1.009	1.015	1.003	1.002	0.999	1.006										
1999									1.004	1.011	1.008	1.012	1.012	1.006	1.001	1.004	1.003											
2000								1.005	1.009	1.010	1.012	1.009	1.008	1.006	1.011	1.004												
2001							1.010	1.013	1.017	1.014	1.021	1.010	1.011	1.002	1.010													
2002						1.011	1.021	1.028	1.024	1.021	1.022	1.012	1.009	1.013														
2003					1.032	1.028	1.033	1.034	1.029	1.025	1.011	1.018	1.008															
2004				1.037	1.038	1.047	1.036	1.044	1.026	1.018	1.011	1.023																
2005			1.067	1.050	1.053	1.052	1.046	1.028	1.019	1.019	1.014																	
2006		1.113	1.087	1.070	1.072	1.062	1.048	1.021	1.015	1.023																		
2007	1.443	1.169	1.112	1.095	1.081	1.042	1.022	1.024	1.036																			
2008	1.517	1.219	1.125	1.097	1.060	1.032	1.026	1.038																				
2009	1.598	1.226	1.131	1.072	1.038	1.029	1.044																					
2010	1.658	1.274	1.107	1.047	1.041	1.045																						
2011	1.632	1.203	1.059	1.038	1.055																							
2012	1.565	1.119	1.057	1.058																								
2013	1.348	1.134	1.111																									
2014	1.385	1.168																										
2015	1.447																											
3-Year Average	1.393	1.140	1.076	1.048	1.045	1.035	1.031	1.028	1.023	1.020	1.012	1.018	1.009	1.007	1.007	1.003	1.002	1.003	1.004	1.003	1.004	1.002	1.005	1.004	1.008	1.005	1.006	1.003
Average xHi Lo	1.512	1.177	1.095	1.061	1.051	1.039	1.033	1.027	1.020	1.017	1.012	1.011	1.008	1.007	1.007	1.005	1.005	1.007	1.007	1.007	1.006	1.005	1.007	1.006	1.005	1.005		
Selected	1.512	1.177	1.095	1.061	1.051	1.039	1.033	1.027	1.020	1.017	1.012	1.011	1.008	1.007	1.007	1.005	1.005	1.007	1.007	1.007	1.006	1.005	1.007	1.006	1.005	1.005	1.006	1.003
Selected Tail Factor	1.005																											
Cumulative	2.811	1.859	1.580	1.443	1.360	1.294	1.245	1.205	1.174	1.151	1.132	1.118	1.106	1.097	1.090	1.082	1.077	1.071	1.064	1.056	1.049	1.043	1.038	1.030	1.024	1.019	1.014	1.008

Workers Compensation
Medical Benefit Cost Level Factors

	(1)	(2)	(3)	(4)	(5)
Accident Year	Medical Fee Schedule Change	Annual "Other Medical" Level Change	Portion of Medical Losses Subject to Fee Schedules	Combined Effect	Factor to Adjust Medical Benefits to Projected Cost Level
2012	0%	2.5%	75.0%	0.6%	0.983
2013	0%	2.0%	75.0%	0.5%	0.978
2014	-20%	4.0%	70.0%	-12.8%	1.122
2015	0%	4.1%	70.0%	1.2%	1.109
2016	10%	3.9%	70.0%	8.2%	1.025
Projected	0%	8.2%	70.0%	2.5%	

(1) Based on evaluations of the cost impact of changes to the Fee Schedule
(1Proj) Selected
(2) Based on a medical component of the Consumer Price Index
(2Proj) Selected (4% annual trend)
(3) Selected based on separate study
(4) = (1) x (3) + [(2) x (1 - (3)]
(5) = [1.0 + (4NextRow)] x (5NextRow)

Workers Compensation
Loss Ratios-Medical Losses Only

	(1)	(2)	(3)	(4)	(5)	(6)
Year	**Projected Loss Cost Premium**	**Reported Medical Losses**	**Medical Loss Development Factor**	**Factor to Adjust Medical Benefits to Projected Cost Level**	**Projected Ultimate Medical Losses**	**Expected Medical Loss Ratio**
2012	$ 4,665,972,903	$ 2,188,888,983	1.360	0.983	$ 2,926,281,904	62.7%
2013	$ 4,845,326,599	$ 1,908,889,082	1.443	0.978	$ 2,693,927,353	55.6%
2014	$ 4,902,840,541	$ 1,576,129,809	1.580	1.122	$ 2,794,099,880	57.0%
2015	$ 5,053,925,714	$ 1,449,781,011	1.859	1.109	$ 2,988,913,475	59.1%
2016	$ 5,157,100,516	$ 954,283,007	2.811	1.025	$ 2,749,551,771	53.3%
Total	$ 24,625,166,273	$ 8,077,971,892			$ 14,152,774,383	57.5%

(1) From Premium Exhibit
(2) Input
(3) From Medical Sheet 1 (Development)
(4) From Medical Sheet 2 (Cost Change)
(5) = (2) x (3) x (4)
(6) = (5) / (1)

Workers Compensation
Paid Allocated Loss Adjustment Expense Development

Age-to-Age Development (in months):

Accident Year	12 to 24	24 to 36	36 to 48	48 to 60	60 to 72	72 to 84	84 to 96	96 to 108	108 to 120	120 to 132	132 to 144	144 to 156	156 to 168	168 to 180	180 to 192	192 to 204	204 to 216	216 to 228	228 to 240	240 to 252	252 to 264	264 to 276	276 to 288	288 to 300	300 to 312	312 to 324	324 to 336	336 to 348
1988																				1.012	1.014	1.013	1.009	1.009	1.008	1.007	1.006	1.005
1989																			1.009	1.009	1.010	1.012	1.006	1.008	1.007	1.005	1.004	
1990																		1.011	1.013	1.010	1.008	1.007	1.008	1.008	1.012	1.008		
1991																	1.040	1.003	1.016	1.011	1.010	1.012	1.010	1.011	1.009			
1992																1.014	1.046	1.010	1.016	1.009	1.009	1.007	1.008	1.009				
1993															0.986	1.014	1.041	1.004	1.011	1.009	1.009	1.010	1.008					
1994														1.019	0.982	1.018	1.033	1.000	1.008	1.004	1.010	1.009						
1995													1.013	1.010	0.984	1.007	1.031	0.999	1.007	1.006	1.005							
1996												1.010	1.009	1.018	0.978	1.006	1.031	1.000	1.006	1.004								
1997											1.010	1.010	1.012	1.011	0.979	1.007	1.031	0.999	1.008									
1998										1.012	1.009	1.014	1.006	1.012	0.979	1.007	1.031	1.001										
1999									1.017	1.012	1.017	1.008	1.004	1.011	0.978	1.006	1.031											
2000								1.025	1.017	1.012	1.007	1.005	1.004	1.013	0.978	1.008												
2001							1.049	1.018	1.017	1.009	1.007	1.009	1.005	1.011	0.979													
2002						1.049	1.044	1.017	1.012	1.008	1.007	1.006	1.004	1.012														
2003					1.057	1.048	1.049	1.015	1.016	1.024	1.009	1.008	1.006															
2004				1.137	1.059	1.054	1.052	1.021	1.018	1.016	1.011	1.013																
2005			1.228	1.130	1.068	1.054	1.051	1.022	1.023	1.018	1.018																	
2006		1.533	1.242	1.141	1.066	1.054	1.057	1.031	1.026	1.023																		
2007	2.231	1.466	1.242	1.130	1.059	1.062	1.065	1.037	1.035																			
2008	2.065	1.459	1.211	1.121	1.067	1.071	1.065	1.037																				
2009	2.109	1.456	1.221	1.134	1.081	1.080	1.067																					
2010	2.317	1.498	1.240	1.159	1.087	1.076																						
2011	2.270	1.532	1.266	1.159	1.087																							
2012	2.356	1.539	1.254	1.156																								
2013	2.344	1.494	1.241																									
2014	2.234	1.484																										
2015	2.271																											
3-Year Average	2.283	1.506	1.254	1.158	1.085	1.076	1.066	1.035	1.028	1.019	1.013	1.009	1.005	1.012	0.978	1.007	1.031	1.000	1.007	1.005	1.008	1.009	1.009	1.009	1.009	1.007	1.005	1.005
Average xHi Lo	2.254	1.495	1.238	1.141	1.070	1.060	1.055	1.024	1.019	1.015	1.010	1.009	1.007	1.013	0.980	1.009	1.034	1.002	1.010	1.008	1.009	1.010	1.008	1.009	1.009	1.007		
Selected	2.254	1.495	1.238	1.141	1.070	1.060	1.055	1.024	1.019	1.015	1.010	1.009	1.007	1.013	0.980	1.009	1.034	1.002	1.010	1.008	1.009	1.010	1.008	1.009	1.009	1.007	1.005	1.005
Selected Tail Factor	1.005																											
Cumulative	6.992	3.102	2.075	1.676	1.469	1.373	1.295	1.228	1.199	1.176	1.159	1.148	1.137	1.129	1.115	1.138	1.128	1.091	1.088	1.078	1.069	1.059	1.049	1.041	1.031	1.022	1.015	1.010

Workers Compensation
ALAE Ratio

	(1)	(2)	(3)	(4)	(5)
Accident Year	**Projected Ultimate Indemnity and Medical Losses**	**Paid ALAE**	**ALAE Development Factor**	**Ultimate ALAE**	**ALAE Ratio**
2012	$ 4,344,989,574	$ 350,034,124	1.469	$ 514,200,128	11.8%
2013	$ 4,426,429,583	$ 336,178,599	1.676	$ 563,435,332	12.7%
2014	$ 4,606,141,447	$ 201,330,551	2.075	$ 417,760,893	9.1%
2015	$ 4,531,776,298	$ 155,896,057	3.102	$ 483,589,569	10.7%
2016	$ 4,716,770,717	$ 93,338,368	6.992	$ 652,621,869	13.8%
Total	$ 22,626,107,619	$ 1,136,777,699		$ 2,631,607,791	11.6%
			(6)	Selected Ratio	11.6%

(1) Derived from Indemnity Sheet 3 and Medical Sheet 3
(2) Input
(3) From LAE, Sheet 1 (Development)
(4) = (2) x (3)
(5) = (4) / (1)
(6) Selected

Workers Compensation
ULAE Ratio

	(1)	(2)	(3)
Calendar Year	**Calendar Year Paid Indemnity and Medical Losses**	**Calendar Year Paid ULAE**	**ULAE as % of Losses**
2012	$ 4,306,514,977	$ 288,536,503	6.7%
2013	$ 4,007,631,598	$ 272,518,949	6.8%
2014	$ 3,641,833,560	$ 320,481,353	8.8%
2015	$ 3,203,661,824	$ 288,329,564	9.0%
2016	$ 3,034,498,823	$ 273,104,894	9.0%
Total	$ 18,194,140,782	$ 1,442,971,263	7.9%

(4) Selected Percentage 9.0%

(1) Input
(2) Input
(3) = (2) / (1)
(4) Selected

Workers Compensation
Overall Indication

	(1)	(2)	(3)	(4)	(5)
Accident Year	**Expected Indemnity Loss Ratio**	**Expected Medical Loss Ratio**	**Expected ALAE Ratio**	**Expected ULAE Ratio**	**Expected Loss & LAE Ratio**
2012	30.4%	62.7%	11.6%	9.0%	112.3%
2013	35.8%	55.6%	11.6%	9.0%	110.2%
2014	37.0%	57.0%	11.6%	9.0%	113.4%
2015	30.5%	59.1%	11.6%	9.0%	108.1%
2016	38.1%	53.3%	11.6%	9.0%	110.2%
Total	34.4%	57.5%	11.6%	9.0%	110.8%

(6) Selected 110.8%
(7) Indication 10.8%

(1) From Indemnity Sheet 3
(2) From Medical Sheet 3
(3) From LAE Sheet 2
(4) From ULAE Sheet 2
(5) = [(1) + (2)] x [1.0 + (3) + (4)]
(6) Selected
(7) = (6) - 1.0

Workers Compensation
Company Adjustment

(1)	**General Expenses**	10.0%
(2)	**Other Acquistion Costs**	8.0%
(3)	**Taxes, License and Fees**	2.5%
(4)	**Commissions and Brokerage Fees**	8.0%
(5)	**Target Profit Provision**	1.5%
(6)	**Total Expense and Profit**	30.0%
(7)	**Expense and Profit Adjustment**	1.429
(8)	**Expected Loss Cost Difference**	-5.0%
(9)	**Operational Adjustment**	0.950
(10)	**Proposed Deviation**	1.358
(11)	**Current Deviation**	1.400
(12)	**Industry Loss Cost Change**	10.8%
(13)	**Company Change**	7.5%

(1)-(5)	Inputs
(6)	= (1) + (2) + (3) + (4) + (5)
(7)	= 1.0 / [1.0 - (6)]
(8)	Selection
(9)	= 1.0 + (8)
(10)	= (7) x (9)
(11)	Given
(12)	From Indication Sheet
(13)	= (10) / (11) x [1.0 + (12)] - 1.0

APPENDIX E: UNIVARIATE CLASSIFICATION EXAMPLE

The following two exhibits show examples of traditional (univariate) classification analysis using a pure premium and loss ratio analysis. Though not explicitly stated, each analysis uses multiple years of exposure, premium, and loss data.

PURE PREMIUM APPROACH

Column 1 displays the earned exposures by class. As discussed in earlier chapters, earned exposures are normally used as the best match to the reported losses.

Column 2 displays the calendar accident year reported loss and ALAE. In this example, loss development and trend are assumed to have a negligible effect on the pure premium relativities and therefore have been ignored. Column 3 displays the pure premium, or average loss and ALAE per exposure. Column 4 converts the pure premiums into pure premium relativities by dividing the pure premium for each class by the total pure premium. Expressing the class experience relative to the total is important for comparing these indicated pure premium relativities to those currently used by the company or used by competitors (assuming those are expressed relative to the total, also). Column 5 shows the current class relativities as specified in the rating manual. The base class is Class J, as evidenced by its relativity of 1.00. Column 6 displays the current class relativities normalized so that the total exposure-weighted average relativity is 1.00. (It is preferable to weight the relativities using premium adjusted to the base class, but exposures are used as a proxy.) By normalizing these relativities, the actuary can compare them on an apples-to-apples basis to the indicated relativities in Column 4.

Column 7 contains the credibility measure for each class. The full credibility standard is 11,050 exposures, and partial credibility is calculated using the square root rule. The 11,050 figure is derived based on the 663 claim standard[57] and an expected frequency of 6%. Column 8 shows the credibility-weighted indicated relativity, which is determined by credibility-weighting the indicated relativities with the normalized current relativities. Another commonly used complement of credibility is the all class pure premium, but that was ruled out due to the significant variation between the classes. Column 9 shows the credibility-weighted indicated relativities after they are adjusted to the base class.

Column 10 displays the selected relativities. Column 11 shows the expected change in premium for each class due to the change between the current and selected manual relativities. The fact that the total exposure-weighted average relativity changed by -0.2% (= 1.2776 / 1.2802 - 1.0) means that if the selected class relativities are implemented without any other changes, the overall premium will change by -0.2%. The base rate needs to be increased, or “offset,” by the reciprocal of that change factor (1.0 / (1.0 + -0.2%)) if no overall premium change is desired (i.e., to make the rate change revenue neutral). Column 12 displays the percent change by class assuming the selected relativities and the base rate offset.

[57] As discussed in Chapter 12, the 663 standard assumes no variation in the size of loss and that there is a 99% chance that the observed value will be within 10% of the true value.

LOSS RATIO APPROACH

Column 1 shows the earned premium at current rate level. Chapter 5 discusses several methods for adjusting premium to present rate level. For the purposes of the relativity analysis, it is critical that the premium be adjusted at the granular level rather than at the aggregate level. In other words, it is not sufficient to use the parallelogram method at the aggregate level if the rate changes varied by the classes being examined.

Column 2 displays the reported loss and ALAE. The same comments about trend and development made in the pure premium approach apply.

Column 3 is the loss ratio for each class and for all classes combined. Column 4 converts the loss ratios to indicated changes by dividing the loss ratio for each class by the loss ratio of all classes combined and subtracting one. The indicated change is the percentage the current class relativities (displayed in Column 8) need to be increased or decreased so that the expected loss ratio will be the same for every class.

Columns 5 through 7 derive the credibility-weighted indicated change. Column 6 shows the calculation of the credibility assigned to each class based on the claim counts shown in Column 5. The full credibility standard is 663 claims, and partial credibility is calculated using the square root rule. Column 7 is the credibility-weighted indicated change where the complement of credibility is no change (i.e., 0%).

The current relativities in Column 8 are adjusted by the credibility-weighted indicated change to determine the credibility-weighted indicated relativities in Column 9. The relativities in Column 9 are adjusted to the base class level in Column 10.

Column 11 contains the selected relativities, and Column 12 is the calculation of the relativity change for each class. The total change in Column 12 is the weighted average of the class changes using premium at current rate level as the weight. This represents the expected change in premium due to the selected class relativity changes, and is the amount the base rate needs to be offset if these relativity changes are to be implemented on a revenue-neutral basis. Column 13 is the change for each class if the selected relativities are implemented and the base rate is offset.

Wicked Good Auto Insurance Company
Classification Relativities

Class	(1) Earned Exposures	(2) Reported Loss & ALAE	(3) Pure Premium	(4) Indicated Relativity	(5) Current Relativity	(6) Normalized Current Relativity	(7) Credibility	(8) Credibility-Weighted Indicated Relativity	(9) Credibility-Weighted Indicated Relativity @ Base Class	(10) Selected Relativity	(11) Relativity Change	(12) Percent Change with Off-Balance
J	16,520	$ 878,200	$ 53.16	0.7831	1.00	0.7811	1.00	0.7831	1.0000	1.00	0.0%	0.2%
K	11,328	$ 740,940	$ 65.41	0.9636	1.15	0.8983	1.00	0.9636	1.2305	1.23	7.0%	7.2%
L	1,266	$ 136,830	$ 108.08	1.5922	1.95	1.5232	0.34	1.5467	1.9751	1.98	1.5%	1.7%
M	12,836	$ 888,582	$ 69.23	1.0199	1.35	1.0545	1.00	1.0199	1.3024	1.30	-3.7%	-3.5%
N	4,200	$ 753,156	$ 179.32	2.6417	3.50	2.7339	0.62	2.6767	3.4181	3.42	-2.3%	-2.1%
P	11,538	$ 518,146	$ 44.91	0.6616	0.85	0.6640	1.00	0.6616	0.8448	0.84	-1.2%	-1.0%
TOTAL	57,688	$ 3,915,854	$ 67.88	1.0000	1.2802	1.0000		1.0016		1.2776	-0.2%	0.0%

(3) = (2) / (1)
(4) = (3) / (Tot3)
(Tot5) = (5) weighted by (1)
(6) = (5) / (Tot5)
(7) = [(1) / 11,050] ^ 0.5 limited to 1.0
(8) = (4) x (7) + [1.0 - (7)] x (6)
(Tot8) = (8) weighted by (1)
(9) = (8) / (Base8)
(Tot10) = (10) weighted by (1)
(11) = (10) / (5) - 1.0
(12) = [1.0 + (11)] / [1.0 + (Tot11)] - 1.0

Wicked Good Auto Insurance Company
Classification Relativities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Class	**Premium at Current Rate Level**	**Reported Loss and ALAE**	**Loss Ratio**	**Indicated Change**	**Number of Claims**	**Credibility**	**Credibility-Weighted Indicated Change**	**Current Relativity**	**Credibility-Weighted Indicated Relativity**	**Credibility-Weighted Indicated Relativity @ Base Class**	**Selected Relativity @ Base Class**	**Relativity Change**	**Percent Change with Off-Balance**
J	$ 1,114,932	$ 878,200	78.8%	2.3%	826	1.00	2.3%	1.00	1.0230	1.0000	1.00	0.0%	2.4%
K	$ 917,284	$ 740,940	80.8%	4.9%	652	0.99	4.9%	1.15	1.2064	1.1793	1.18	2.6%	5.0%
L	$ 166,314	$ 136,830	82.3%	6.9%	124	0.43	3.0%	1.95	2.0085	1.9633	1.96	0.5%	2.9%
M	$ 1,162,236	$ 888,582	76.5%	-0.6%	866	1.00	-0.6%	1.35	1.3419	1.3117	1.31	-3.0%	-0.7%
N	$ 1,056,318	$ 753,156	71.3%	-7.4%	736	1.00	-7.4%	3.50	3.2410	3.1681	3.17	-9.4%	-7.3%
P	$ 666,978	$ 518,146	77.7%	0.9%	490	0.86	0.8%	0.85	0.8568	0.8375	0.84	-1.2%	1.1%
TOTAL	$ 5,084,062	$ 3,915,854	77.0%	0.0%	3,694							-2.3%	0.0%

(3) = (2) / (1)
(4) = (3) / (Tot3) - 1.0
(6) = [(5) / 663] ^ 0.5 limited to 1.0
(7) = (4) x (6) + 0.0% x [1.0-(6)]
(9) = [1.0 + (7)] x (8)
(10) = (9) / (Base9)
(12) = (11) / (8) - 1.0
(Tot12) = (12) weighted by (1)
(13) = [1.0 + (12)] / [1.0 + (Tot12)] - 1.0

APPENDIX F: MULTIVARIATE CLASSIFICATION EXAMPLE

This appendix includes example output from a GLM analysis. It includes several tests used to evaluate the predictive power of a potential rating variable and hold-out sample testing used to evaluate the overall effectiveness of a particular model.

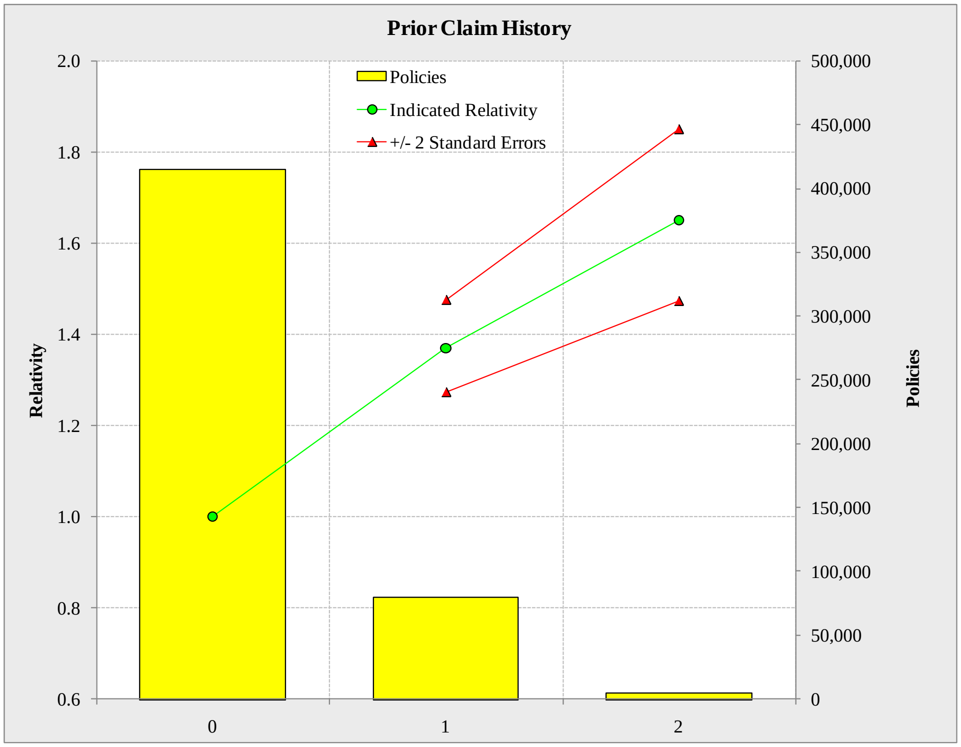
EXAMPLE PREDICTIVE VARIABLE

This section contains sample output from a multiplicative GLM fit to homeowners water damage frequency[58] data. The graphical output isolates the effect of the prior claim history variable as a significant predictor of water damage frequency, though the model contains other explanatory variables that must be considered in conjunction with the prior claims history effect.

Parameters and Standard Errors

The following graph displays the indicated frequency relativities for prior claims history, all other variables considered. The categories on the x-axis represent the levels of the variable (0, 1, or 2 claims). The level for zero prior claims is the base level, and the relativities for the other levels are expressed relative to it. The bars relate to the right y-axis, showing the number of policies in each level. The line with the circle marker shows the indicated relativities, and the lines with the triangle markers represent two standard errors on either side of the indicated relativities.

F.1 Main Effect Test for Prior Claim History



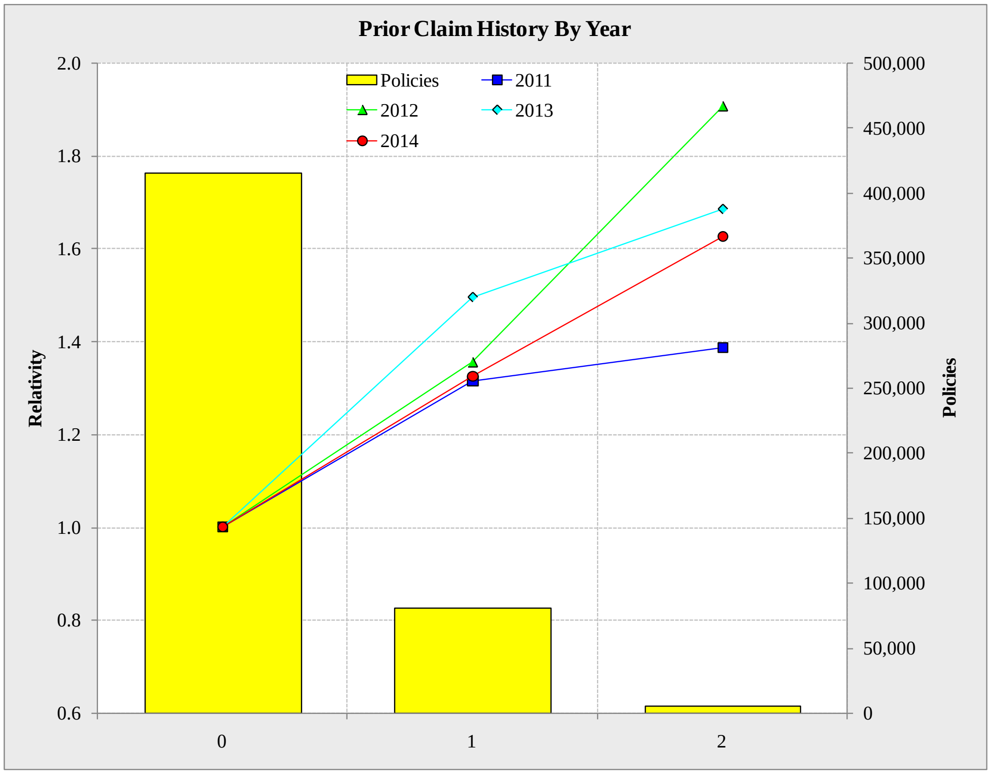
[58] It is common for actuaries to build frequency and severity models for each major peril or cause of loss.

The fact that the indicated relativity line is upward sloping with relatively tight standard errors suggests that the expected frequency is higher for risks with prior claims. More specifically, risks with one or two prior claims have a frequency that is approximately 35% and 65% higher than risks with no prior claims.

Consistency Test

The prior graph shows the indicated relativities for the whole dataset. The following graph shows the pattern of relativities for each of the individual years included in the analysis. (In some cases, the actuary may use random segments of the dataset rather than individual years.) Like the last figure, the categories on the x-axis represent the number of prior claims, and the bars are the number of policies in each level. The lines represent the indicated frequency relativities for prior claims history, separately for each year.

F.2 Consistency Test for Prior Claim History



The fact that each year's indicated line slopes upward with roughly the same shape suggests that the pattern is consistent over time. This provides the actuary with a practical test supporting the stability of this variable's predictive power.

Statistical Test

The actuary can also test the predictive power of a variable using statistical diagnostics such as deviances. One common deviance test is the Chi-Square test. In this test, the actuary fits models with and without the variable being studied and analyzes the trade-off between the increased accuracy of the model with the variable included versus the additional complexity of having additional parameters to estimate. The null hypothesis is that these two models are essentially the same. A Chi-Square percentage is calculated based on the results of the two models. A Chi-Square percentage of less than 5% generally suggests the actuary should reject the null hypothesis that the models are the same and should use the model with the greater number of parameters.

In this example, the Chi-Square percentage is 0%. Thus, the actuary rejects the null hypothesis and selects the model with the greater number of parameters. In other words, the actuary selects the model with the prior claims history variable in it.

Judgment

It is important that the actuary evaluate the reasonableness of the model and diagnostic results based on knowledge of the claims experience being modeled. In this case, the statistical results are consistent with the intuitive expectation that frequency is higher with the presence of prior claims.

Decision

All four tests suggest the rating variable is predictive and should be included in the model (and ultimately the rating algorithm).

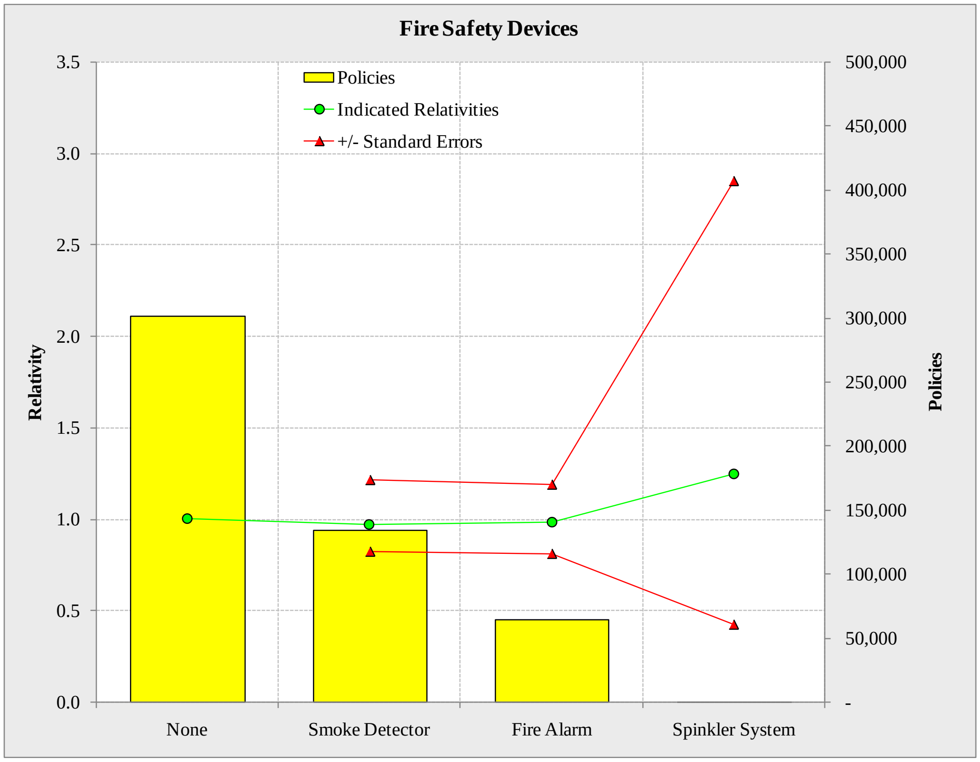
EXAMPLE UNPREDICTIVE VARIABLE

This section contains sample output from a multiplicative GLM fit to homeowners wind damage frequency data. The output isolates the effect of fire safety devices as an insignificant predictor of wind damage frequency, though the model contains other explanatory variables that must be considered in conjunction with this variable.

Parameters and Standard Errors

The following graph shows the indicated frequency relativities for the fire safety device variable, all other variables considered. The x-axis categories represent the different fire safety devices (the base being the level “none”), and the bars are the number of policies in each level. The lines represent the indicated wind damage frequency relativities and two standard errors on either side of the indicated relativities.

F.3 Main Effect Test for Fire Safety Device

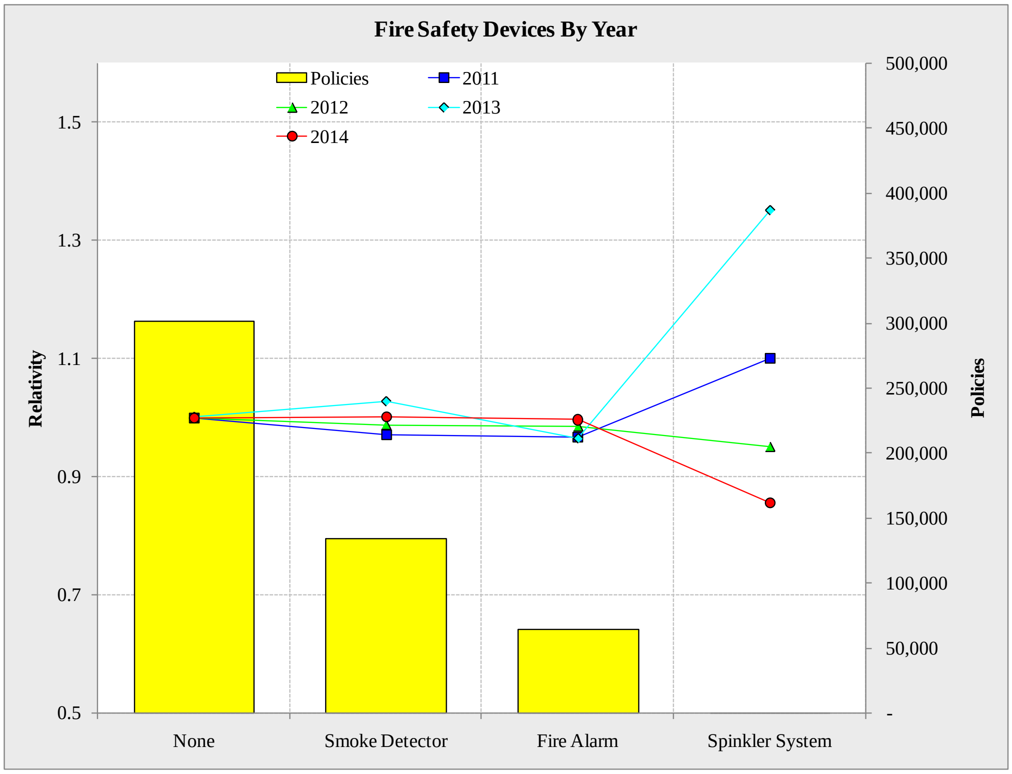


The indicated line is basically flat (i.e., indicated relativities are close to 1.00) for the levels that have a significant number of policies. The one category that has an indication substantially different than 1.0 (sprinkler system) has very wide standard errors around the indicated relativity, which is likely due to the small number of policies in that category. Thus, there appears to be little predictive power in this variable, and it should be removed from the wind damage frequency model.

Consistency Test

The following figure shows the pattern for each of the individual years included in the analysis. Like the last graph, the categories on the x-axis represent different fire safety devices, and the bars are the number of policies in each level. The lines represent the indicated relativities for each year.

F.4 Consistency Test for Fire Safety Device Claim



The patterns are consistent across the years for all categories but the sprinkler system. That category has little data, and the predictions are very volatile. These results confirm the conclusions derived from the parameter results and standard errors.

Statistical Test

The Chi-Square percentage for this variable is 74%. Percentages above 30% indicate that the null hypothesis, which asserts the models are the same, should be accepted. If the models are "the same," then the actuary should select the simpler model that does not include the additional variable. (Chi-Square percentages between 5% and 30% are often thought to be inconclusive based on this test alone.)

Judgment

The existence of smoke detectors, sprinklers, and fire alarms does not seem to have any statistical effect on the frequency of wind damage losses. This is consistent with intuition.

Decision

All four tests suggest the rating variable is not predictive and should be excluded from the wind damage frequency model.

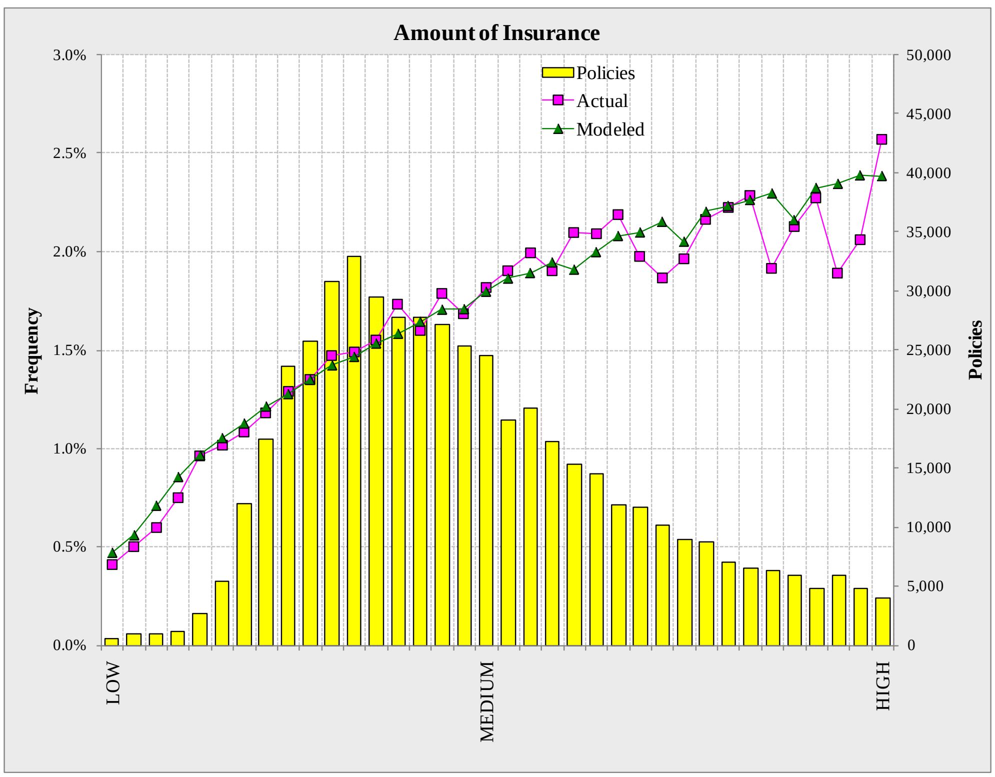
OVERALL MODEL VALIDATION

There are many tests that analyze the overall effectiveness of a given model, the most common of which compares predictions made by the model to actual results on a hold-out dataset (i.e., data not used to develop the model). This test does require that companies set aside a portion of the data for testing; this may not always be possible for smaller companies.

Validation Test Segmented by Variable

The following graph shows the observed and predicted frequencies for various levels of amount of insurance. If the model is predictive, then these frequencies should be close for any level with enough volume to produce stable results. The random nature of the insurance process will create small differences between the lines; however, either large or systematic differences or both should be investigated as possible indicators of an ineffective model. For example, the model may contain too much noise caused by retaining statistically insignificant variables or not have enough explanatory power because statistically significant variables are omitted.

F.5 Actual Results v Modeled Results for AOI

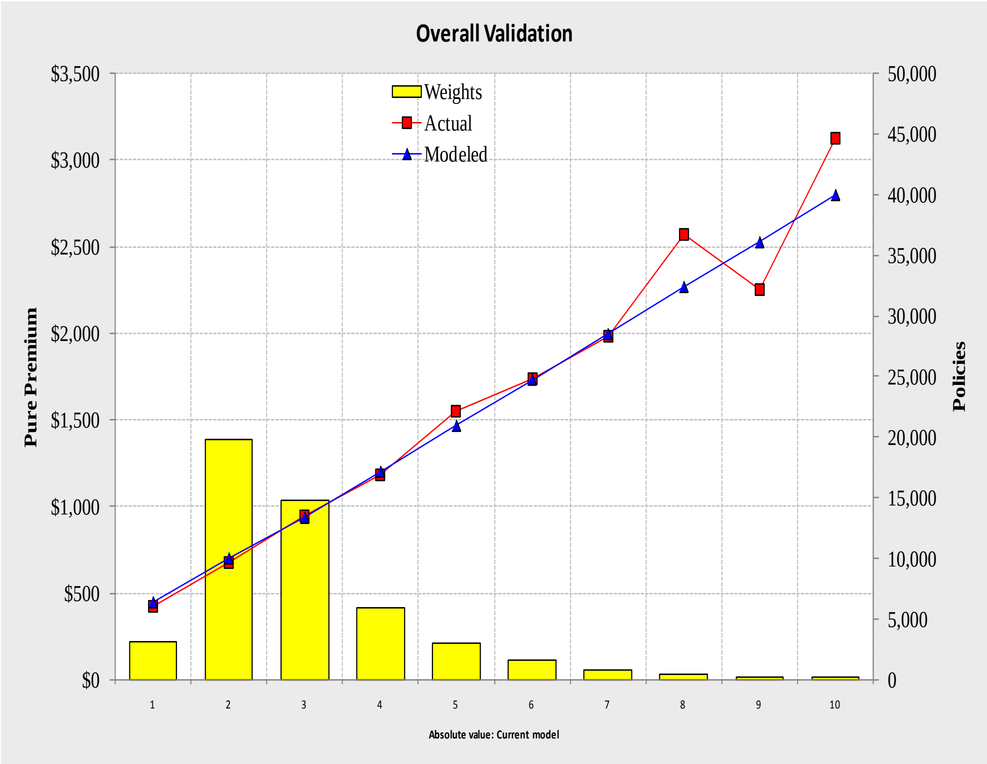


In viewing this graph, it is important to note that amount of insurance is a variable for which there is a natural order to the different levels (i.e., amount of insurance $201,000 is between amounts of insurance $200,000 and $202,000). In general, the results show a close match between expected frequencies from the model and actual claim frequencies. In particular, however, the modeled results for the first four levels appear to be higher than the actual results, suggesting that the model may be over-predicting the frequency for homes with low amounts of insurance. Similar-sized discrepancies can be seen for the medium amounts of insurance (where the actual results appear higher than the modeled results) and the high amounts of insurance (where the actual results appear lower than modeled results but with considerable volatility).

Validation Test Segmented by Fitted Value

In the following figure, the underlying frequency and severity models were used to determine a modeled pure premium for each observation in a hold-out dataset. Then, each observation was ordered according to the modeled pure premium result from the lowest to highest expected value. The observations were then grouped into 10 groups, and the actual and modeled results for each group are compared on the same chart. If the model is predictive, the actual result will be close to the modeled result for each group. Special attention should be paid to the lowest and highest groups where the results are more likely to deviate as models are generally less able to predict observations at the extremes.

F.6 Actual Results v Modeled Results



In this case, the actual results are very close to the modeled results for the first seven groups. There appears to be a lot of difference between actual and modeled results for the last few groups, but the low volume in those groups suggests the results may be distorted by noise and therefore less valid.

CHANGES

Changes incorporated in Version 4 (October 2010)

Several editorial changes have been incorporated in this version in order to correct errata and to clarify or rearrange items for enhanced understanding. The following list contains the more substantial edits to content, but it is not meant to be an exhaustive list of changes. The changes in Chapter 14 are the most extensive and should be reviewed carefully.

- Chapter 2 – The following aspects of the Medical Malpractice Rating Manual Example have been modified: the claims-free discount applies to the individual nurse and the extended reporting factors in Table 2.20B are based on the number of years of prior claims-made coverage.
- Chapter 4 – The definition of unearned exposure now varies by type of aggregation (specifically a calendar year definition was added).
- Chapter 4 – The discussion of in-force exposure has been revised to reflect the various ways companies define this term. The tabular examples define in-force exposure in terms of the number of homes insured at a point in time.
- Chapter 4 – Two new tables have been added to demonstrate policy year aggregation for semi-annual policies.
- Chapter 5 – The definition of unearned premium now varies by type of aggregation (specifically a calendar year definition was added).
- Chapter 6 – The numeric value for the 20-point linear trend has been corrected.
- Chapter 6 – Language has been added to address the development of a non-modeled catastrophe pure premium (since this type of procedure is included in Appendix B).
- Chapter 6 – New graphics have been added to the loss trend section.
- Chapter 8 – New language has been added to address how to combine several years of data in the actuarial estimate.
- Chapter 9 – The discussion of the pure premium, loss ratio, and adjusted pure premium approaches has been revised to address more specifically the application of loss development, trend, and ULAE.
- Chapter 10 – Language for the second benefit of multivariate methods has been modified.
- Chapter 11 – An example has been added for the Trended Present Rates method.
- Chapter 11 – The formula for the Fitted Curves method (% losses in the layer) has been corrected.
- Chapter 12 – The formulae in the Classic Credibility Approach have been modified. The expected value for the total value of losses (E(S)) is used rather than the expected value for the total number of claims (E(Y)) prior to certain simplifying assumptions being made. Also, the value from the Standard Normal Table is correctly shown as $Z_{(p+1)/2}$.
- Chapter 13 – Column 10 (Present Value of Premium) in the Lifetime Customer Value tables has been corrected. This changes the numeric answers, but not the underlying conclusion.

- Chapter 14 – The fixed expense fee in the example rating algorithm is now per exposure rather than per policy. This changes many formulae in this chapter.
- Chapter 14 – The example data used in both the Approximated Average Rate Differential Method and the Change in Average Rate Differential Method no longer amalgamates exposure and premium across all combinations of discounts D1 and D2. The approach in the original text made the variable premium portion of the rating algorithm entirely multiplicative. The new approach addresses the additive nature of the discounts, which necessitated changes in the formulae and numeric answers.
- Chapter 14 – The section regarding premium change caps on individual rating levels has been revamped to walk the read through the individual calculations. A correction has also been made to the Proposed Premium from Non-Capped Levels (the original text calculated current premium from non-capped levels).
- Chapter 15 – In the composite rating plan example, the monetary denomination in each exposure base has been clarified – e.g., revenue in $000s.
- Chapter 15 – The policy limit has been changed in the example calculation for composite rating plan for loss-rated policies large deductible limit. No calculations in this example were affected.
- Chapter 15 – The paragraphs addressing the Basic Premium formula and the treatment of expenses in the Retro Premium formula have been revised.
- Appendix B – The fixed expenses are trended for each year individually and then a selection is made. This did not change any numeric values in the indication.
- Appendix D – The valuation date of the experience is correctly shown as December 31, 2016 (not 2015).
- Appendix D – The calendar years used in the ULAE exhibit have been modified.
- Appendix D – The loss trend date is correctly shown as July 1, 2018 (not 2017).
- Appendix D – The footnote for Row 9 in the company exhibit has been corrected to 1.0 + (8).