The Stanard-Bühlmann Reserving Procedure— A Practitioner's Guide

Sholom Feldblum, FCAS, FSA, MAAA

Stanard-Bühlmann Reserving Procedure

The Stanard-Bühlmann procedure is a major advance in casualty actuarial loss reserving methods. It has proved especially useful for reinsurers lacking the pricing data to perform Bornhuetter-Ferguson analyses. Primary companies may benefit equally from this technique, particularly if the pricing actuary's expected loss ratio is not consistent with actual experience.

The Stanard-Bühlmann technique is similar to two other modified expected loss procedures: the Cape Cod method and the "adjustment to total known losses" (see Stanard [1985]). These are all methods of using the expected loss procedure when expected loss ratios are not available. We explain the similarities in this practitioner's guide, so that reserving actuaries may more knowledgeably choose among the techniques.

The Stanard-Bühlmann procedure is an intuitive procedure. Its European genealogy and its reinsurance provenance give it an undeserved aura of mathematical complexity, deterring some actuaries from its chárms. If fact, it is a simple and sensible technique, forming an excellent adjunct to the common chain ladder procedures.

Structure of this Guide

We explain the intuition underlying chain ladder reserving techniques and expected loss reserving techniques. We show the algebraic extension of the Bornhuetter-Ferguson expected loss reserving technique to the Stanard-Bühlmann technique.

This practitioners' guide emphasizes the concepts; the algebraic implementation is straightforward. We examine the intuition underlying the Stanard-Bühlmann method and the required adjustments to premium. We present several illustrations to show the simplicity of this method and the various reserving applications for which it is applicable.

RESERVING PRINCIPLES

The fundamental principle underlying most actuarial reserving techniques is that certain loss reporting patterns or loss settlement patterns remain relatively stable over time. The past observations, adjusted (if necessary) for changes in the insurance environment and company claims practices, are a reasonable predictor of future experience.

Examples of this principle are statements such as

- Case incurred losses as of 24 months since inception of the accident year are expected to be 50% higher than case incurred losses as of 12 months for that accident year.
- Cumulative paid losses as of 48 months since inception of the accident year are expected to be 20% higher than cumulative paid losses as of 36 months for that accident year.

The format of the two statements above is that the cumulative losses (of whatever type) as of development period $i+1$ are X% greater or lower than the same cumulative losses as of development period i, is the application of the principle to a specific reserving technique, the chain ladder procedure. The format differs for other reserving techniques, such as the Stanard-Bühlmann method.

The fundamental principle is that there is stability in the loss reporting pattern or in the loss settlement pattern. The loss reserving methods differ in the base against which we measure the stability.

ILLUSTRATION: PATTERNS OF STABILITY

Past observations indicate that losses of $550,000 would be paid over a five year period in the following fashion:

Development Months	0 – 12	12 – 24	24 – 36	36 – 48	48 – 60
Paid Losses	$100,000	$200,000	$150,000	$75,000	$25,000

We formulate the observed pattern in several ways.

A. *Incremental Development:* Losses paid between 12 months and 24 months are equal to twice the losses paid between 0 months and 12 months. Losses paid between 24 months and 36 months are equal to ¾ of the losses paid between 12 months and 24 months.

B. *Cumulative Development:* The cumulative losses paid between 0 months and 24 months are equal to 3 times the cumulative losses paid between 0 months and 12 months. The cumulative losses paid between 0 months and 36 months are equal to 1.500 times the cumulative losses paid between 0 months and 24 months.

C. *Percentages of Ultimate:* Of the $550,000 total paid losses, 18.2% are paid in the first 12 months, and 36.4% are paid in the next 12 months.

These patterns differ in the measurement base. The patterns are shown in the table below:

Development Months	0 – 12	12 – 24	24 – 36	36 – 48	48 – 60
Paid Losses	$100,000	$200,000	$150,000	$75,000	$25,000
Incremental ratio		2.000	0.750	0.500	0.333
Cumulative ratio		3.000	1.500	1.167	1.047
Percent of ultimate	0.182	0.364	0.273	0.136	0.045

The manner of expressing the pattern depends on the measurement base.[1]

[1] Brosius [1993: "Loss Development Using Credibility"] presents a statistical procedure for selecting the base. The Brosius procedure allows for multiple bases – such as 60% of one base plus 40% of another base, and it determines the optimal percent of each.

For the expected losses, the bases in the example above can be converted into one another. If we are told the "incremental ratio" pattern, we can derive the "cumulative ratio" pattern and the "percent of ultimate" pattern.

The chain ladder method uses the cumulative ratio basis. The paid loss link ratio from 36 to 48 months is the 1.167 in the 36 to 48 months column of the cumulative ratio row. The cumulative product of the link ratios from a given development date forward is the loss development factor. The loss development factor from 36 months to ultimate is 1.167 × 1.047 = 1.222.

The percent of ultimate row is used for both the Bornhuetter-Ferguson method and the Stanard-Bühlmann method. The Bornhuetter-Ferguson factor is the sum of the percent of ultimate figures from a given development date forward. For instance, the Bornhuetter-Ferguson factor from 36 months to ultimate is 0.136 + 0.045 = 0.181.

The Bornhuetter-Ferguson factor equals 1 – (1 divided by the link ratio). In this example, 0.181 = 1 – (1 ÷ 1.222).

The loss lag used in the Stanard-Bühlmann method is the complement of the Bornhuetter-Ferguson factor. The loss payment lag at 36 months is 1 – 0.181 = 0.819.

DETERMINING THE PATTERNS

There are various ways of determining these patterns. The prospective future pattern is generally based on the historical observed patterns, with several adjustments.

- *Averages:* We might use either unweighted averages or weighted averages of historical observations, such as the cumulative link ratios in the experience period. When the weights are the same as the measurement base – e.g., the weights are the losses at the start of the period for the chain ladder link ratios – the weighted average may be computed by taking the totals for several years.[2]

- *Outliers:* We might eliminate outliers. For instance, we might use averages which discard

---

[2] Weighted averages are preferable when the differences in volume stem from differences in exposures. Unweighted averages are preferable when the differences in volume stem from monetary inflation. The Mahler paradigm of shifting risk parameters implies that more weight be given to the more recent years. Mahler's advances in credibility theory are particularly applicable to loss reserving, since the covariance matrix can be estimated from the experience.

the high value and the low value.

- *Inflation:* Changing inflation rates may bias the projected pattern. To correct for changes in the inflation rate, we might deflate the historical triangle for past inflation, perform the actuarial analysis on "real dollar" figures, and project forward with future expected inflation or stochastic inflation rate paths (cf. Hodes, Feldblum, and Blumsohn [1999]).

- *Trend and other Adjustments:* When the insurance environment is changing, we might trend the historical figures. Examples with significant effects are changing attorney involvement in private passenger automobile claims and changing claims management practices in workers' compensation insurance. For small insurers, we might weight company averages with industry averages, or state averages with countrywide averages.

Once we determined any one pattern, we have determined the other patterns as well. One sometimes hears that all of these methods start with the expected link ratios. We could equally well say that all these methods start with the expected Bornhuetter-Ferguson factors or with the expected loss lags.

FUTURE VALUES

The determination of the factors is the same for all three reserving methods. The use of the factors differs among the reserving methods.

- For chain ladder methods, we apply the expected factors to the cumulative paid or reported losses for each experience year. We do not need the estimated ultimate losses for the block of business.
- For the Bornhuetter-Ferguson method, we apply the factors to the estimated ultimate losses for the block of business. We do not need the cumulative paid or reported losses for each experience year.

In the example above, the paid losses in the first 12 months equal 18.2% of the estimated ultimate paid losses. Suppose we are using this historical pattern to estimate the needed reserves for a more recent accident year. What if the paid losses in the first 12 months of this accident year equal 25% of the estimated ultimate losses, not 18.2% of the ultimate losses?

- The chain ladder method says: "Use the cumulative paid losses in the first 12 months; ignore the estimated ultimate losses."

- The Bornhuetter-Ferguson method says: "Use the estimated ultimate losses; ignore the cumulative paid losses in the first 12 months."

CHOICE OF METHOD

Brosius, following Hugh White's discussion of the Bornhuetter-Ferguson paper, explains the differing philosophy of these two alternatives.

- The chain ladder method assumes that unusually high or low cumulative paid losses to date is indicative of correspondingly high or low paid losses in future development periods.
- The Bornhuetter-Ferguson method assumes that unusually high or loss cumulative paid losses to date reflects random loss fluctuations. This is not indicative of unusually high or low paid losses in the remaining development periods.

As Brosius points out, the truth is generally in between these two alternatives.

Yet the extreme cases interest us, because certain attributes of the insurance scenario argue for one or the other of these cases.[3]

---

[3] See Bornhuetter-Ferguson [1972] and Brosius [1993].

- When losses are very immature, or when loss severity is large but loss frequency is low, or when the variability of losses is unusually great, the Bornhuetter-Ferguson expected loss method may be favored.
- When losses are mature, or when loss severity is low but loss frequency is high, or when the variability of losses is small, the chain ladder method may be favored.

Excess of loss reinsurance has the former attributes, so many reinsurance actuaries are inclined to use expected loss reserving procedures. But there is a problem with expected loss procedures as applied to reinsurance.

ESTIMATED ULTIMATE LOSSES

The Bornhuetter-Ferguson method needs an estimate of the ultimate losses. For primary companies, this may not be a problem. Pricing actuaries estimate ultimate losses to set premium rates. The reserving actuary can use the estimate provided by the pricing actuary.

The estimated ultimate losses equal the premium times the expected loss ratio. This estimate is suitable when the indicated premium is also the premium charged. The estimate must be adjusted when the premium in the rate manual is not the pricing actuary's indicated premium. It must be further adjusted when underwriters provide schedule credits and debits to individual insureds, as is commonly done in the commercial lines of business. These adjustments demand business acumen, but a knowledgeable reserving actuary can sometimes make a reasonable estimate of the ultimate losses.

The reinsurer's reserving actuary does not have the data needed for this. The reinsurer's reserving book of business may consist of disparate pieces with different expected loss ratios. The reinsurer does not have the information to adjust for the adequacy level of the primary premiums or for schedule credits and debits provided by the primary underwriters.

This is also true for primary insurance enterprises if the reserving actuary does not have access to the pricing actuary's estimates, to manual deviations from indicated rates, or to the underwriters' discretionary price modifications. This is often the case for large commercial lines insurers.

Stanard-Bühlmann

Two eminent actuaries, James Stanard and Hans Bühlmann, provided a solution. If we have sufficient past experience, they argued, we don't need to know the expected loss ratio. We simply need to adjust all premiums in the historical period to the same level of adequacy.

The needed adjustments to the premiums are straightforward. However, these adjustments will divert us from the intuition underlying their reserving technique. For the moment we skip these adjustments; we explain them further below. For our first set of illustrations, assume that premiums are at the same level of adequacy for each year.

Let us clarify the assumption. We do not know the expected loss ratio for any year. But whatever the expected loss ratio is, it is the same for all years.

We use a numerical example to illustrate the Stanard-Bühlmann method. In practice, this method is most useful for long-tailed lines of business with relatively little reported loss or paid loss in the first 2 or 3 years of development. For heuristic purposes, we use a simpler example.

Determining the Pattern

The first task is to determine the pattern that is assumed to remain stable. For the Stanard-Bühlmann method, as for the other expected loss methods, the "percent of ultimate" pattern is assumed to remain relatively stable from year to year.

Stable percentages of ultimate is the assumption that we use to determine the outstanding losses. It is *not* necessarily the assumption we use to *determine the pattern.*

We said above that if we determine the incremental ratios or the cumulative ratios, we know the percentages of ultimate. Conversely, if we determine the percentages of ultimate, we know the incremental ratios and the cumulative ratios. We ask: "Which is the easiest pattern to determine?" not "Which pattern do we want to use?"

This question is surprisingly easy to answer. If we try to determine the percentages of ultimate, we can't use all the data at our disposal. In particular, we can't use any of the most current data. If we try to determine the incremental ratios or the cumulative ratios, we use all the historical data, including the most recent data.

Let us explain. If we try to determine the percentages of ultimate, we can use only mature accident years that have developed to ultimate. The patterns may have changed in the intervening years, as the social, economic, and insurance environments changed.

If we use incremental ratios or cumulative ratios, we can use all accident years, including even the most recent calendar year information in each accident year. This was the advance in casualty loss reserving theory that gave rise to the chain ladder method.[4]

We still must choose between the incremental ratios and the cumulative ratios. At early development periods, both methods work reasonably well. At later development periods, the incremental reported losses and even the incremental paid losses are relatively small. Small figures in the numerator of the ratios do not distort the estimation procedure. But small figures in the denominator of the ratios cause ratios that may be unrealistically large, reducing the accuracy of the results and adding significant bias.

Illustration: The table below shows reported loss development from ten years to 12 years. The table has five accident years and five columns, showing

- cumulative reported losses at ten years of development,
- incremental reported losses in year 11,
- cumulative reported losses at eleven years of development,
- incremental reported losses in year 12, and
- cumulative reported losses at 12 years of development.

All figures are in thousands of dollars.

Accident Year (1)	Reported Losses at Ten Years (2)	Incremental Losses in Year Eleven (3)	Reported Losses at Eleven Yrs (4)	Incremental Losses in Year Twelve (5)	Reported Losses at Twelve Yrs (6)
20X0	100,000	100	100,100	1,100	101,200
20X1	110,000	1,100	111,100	0	111,100
20X2	120,000	0	120,000	1	120,001
20X3	130,000	–100	129,900	1,100	131,000
20X4	140,000	1	140,001	100	140,101

The age-to-age link ratio from year 11 to year 12 is stable when using cumulative reported losses but is not stable when using incremental reported losses.

[4] Health actuaries often use "claim completion percentages," which are chain ladder paid loss development factors that rely on mature years only. Since medical claims are settled quickly, the reliance on mature experience periods is not onerous; see Bluhm, *Group Insurance*, chapter 30. For a typology of reserving procedures, see Saltzman [1984].

Accident Year (1)	Age-to-Age Factor Using Cumulative Reported Losses (7) = (6) / (4)	Age-to-Age Factor Using Incremental Reported Losses (8) = (5) / (3)
20X0	1.011	11.000
20X1	1.000	0.000
20X2	1.000	∞
20X3	1.008	–11.000
20X4	1.001	100.000

This is the rationale for the method of determining the pattern. All three reserving procedures – chain ladder, Bornhuetter-Ferguson, and Stanard-Bühlmann – begin by estimating link ratios (or cumulative age-to-age factors).

Loss development factors are determined as the cumulative products of the link ratios. The loss lags used in the Stanard-Bühlmann procedure, as well as the Bornhuetter-Ferguson factors, are percent of ultimate ratios.

- The reported loss lag is the percent of expected ultimate losses that have been reported by the development date.
- The paid loss lag is the percent of expected ultimate losses that have been paid by the development date.
- The loss lag equals the reciprocal of the loss development factor.
- The Bornhuetter-Ferguson factor is the complement of the loss lag, or "1 – loss lag."

Illustration: Reported loss link ratios for a block of business are shown below. We compute the corresponding loss development factors, loss lags, and Bornhuetter-Ferguson factors.

Development Months	12 – 24	24 – 36	36 – 48	48 – 60	60 – ult
Link ratio	1.500	1.250	1.100	1.050	1.020

The loss development factors are the cumulative products of the link ratios. The loss development factor from 12 months to ultimate equals

$$1.500 \times 1.250 \times 1.100 \times 1.050 \times 1.020 = 2.209.$$

The loss lag at 12 months equals 1 / 2.209 = 0.453. The Bornhuetter-Ferguson factor at 12 months equals 1 – 0.453 = 0.547.

Development Months	12 mos.	24 mos.	36 mos.	48 mos.	60 mos.
Link ratio	1.500	1.250	1.100	1.050	1.020
Loss development factor	2.209	1.473	1.178	1.071	1.020
Loss lag	0.453	0.679	0.849	0.934	0.980
B-F factor	0.547	0.321	0.151	0.066	0.020

ALGEBRA

We show first the algebraic derivation of the Stanard-Bühlmann method from the Bornhuetter-Ferguson method, which is better known to many readers. The algebra is straightforward. The elegance of the technique is the intuition, which we discuss next.

Illustration: We have determined the following percentages of losses that are reported by each development date from the inception of the accident year. The slow loss reporting pattern is characteristic of casualty excess-of-loss reinsurance, products liability, and professional liability.

Loss Lag	Percent Reported	Loss Lag	Percent Reported
12 mos	30%	72 mos	85%
24 mos	50%	84 mos	90%
36 mos	65%	96 mos	94%
48 mos	75%	108 mos	97%
60 mos	80%	120 mos	99%

At December 31, 20X9, we have the following data on premiums and reported losses for the ten most recent accident years.

Year	Adjusted Premiums	Reported Losses	Year	Adjusted Premiums	Reported Losses
20X0	200 million	150 million	20X5	300 million	185 million
20X1	220 million	155 million	20X6	320 million	205 million
20X2	240 million	200 million	20X7	340 million	155 million
20X3	260 million	175 million	20X8	375 million	185 million
20X4	280 million	215 million	20X9	400 million	75 million

Premiums and Losses

Adjusted premiums are premiums on the same level of adequacy for all accident years. We have not yet explained what adjustments are needed to bring premiums to the "same level of adequacy"; we deal with that issue further below. We comment here on two items.

1. There is no need for an absolute level of adequacy. The premiums may be 20% inadequate in each year, or they may be 10% redundant in each year. It won't make any difference for the reserve indication.

2. For the reserving technique to be useful, the reserving actuary must be able to make the needed adjustments. If the actuary had to examine past rate reviews to determine the adequacy of the rates, the reserving technique would have only limited applicability.

   We do not mean that knowledge of the underlying data is irrelevant. No matter what reserving procedure is used, an understanding of the underlying data improves the reserve indications. We are saying only that this knowledge not any more essential for the Stanard-Bühlmann technique than it is for other reserving techniques.

The premium adjustments are relatively easy, if the intuition for the adjustments is clear. We return to this subject below.

The Stanard-Bühlmann technique may be used with either reported losses or paid losses and with either dollars of loss or with number of claims.[5] The type of premium adjustment differs for dollars of loss versus number of claims; see below.

[5] The separate quantification of loss frequency and loss severity allows for estimation of loss frequency along development rows and estimation of average severity by inflation indices.

SIMULTANEOUS EQUATIONS

To keep the intuition clear, we use a pair of simultaneous linear equations. The mathematics can be reduced to a single expression.

If the premiums are at the same adequacy level, then the multiplicative factor needed to arrive at the expected losses is the same for all years. For instance, if the premiums are all 20% inadequate, then the expected losses in each year equal

premium × 1.200 × expected loss ratio.[6]

Let Z = the expected loss ratio times the factor needed to bring premiums to adequate levels.
Let Y_i = the bulk reserves for year *"i."*
Let Y = the total bulk reserve; that is, $Y = \sum Y_i$.

The index *"i"* ranges from 0 to 9, corresponding to accident years 20X0 through 20X9.

We write the Bornhuetter-Ferguson expected loss equations for years 0 through 9. For any year, the bulk loss reserves equal

premium at an adequate level × the expected loss ratio × expected percentage unreported.

For year 20X0, the expected percentage already reported is 99%, so the Bornhuetter-Ferguson estimate of the bulk reserves is

$$\$200 \text{ million} \times Z \times (1 - 99\%) = Y_0$$

We do the same for each accident year. For the 20X9 accident year, the estimate is

$$\$400 \text{ million} \times Z \times (1 - 30\%) = Y_9$$

We sum all 10 equations to get

$$Z \times [\$200 \text{ million} \times (1 - 99\%) + \ldots + \$400 \text{ million} \times (1 - 30\%)] = \sum Y_i = Y.$$

---

6 The terms "premium adequacy" and "expected loss ratio" have numerous interpretations. When used in a pricing context, premium adequacy generally has an economic meaning: premiums are adequate if they provide a reasonable return to the insurance enterprise. Statutory reserving uses undiscounted losses. By "premium adequacy" and "expected loss ratio" in this paper we mean figures such that ultimate (undiscounted) losses equal adequate premiums times the expected loss ratio.

This is a linear equation in two variables, Z and Y.

From the definition of the expected loss ratio, we know that over a long period of time, the total reported losses plus the total bulk reserves should be close to the total expected losses. We write the equation for this statement as

$$[\$150 \text{ million} + \ldots + \$75 \text{ million}] + Y = Z \times [\$200 \text{ million} + \ldots + \$400 \text{ million}]$$

This is also a linear equation in two unknowns, Y and Z.

To solve this pair of linear equations, we compute the three sums in these equations.

- The sum of the adjusted premiums is $2,935 million
- The sum of the reported losses is $1,700 million
- The sum of the adjusted premiums × the Bornhuetter-Ferguson factors is $817.5 million

The two equations are

$$Z \times \$817.5 \text{ million} = Y$$
$$\$1700 \text{ million} + Y = Z \times \$2935 \text{ million}$$

We can solve these two equations for the values of "Y" and "Z." We need to find "Y," the total bulk reserve. We eliminate Z by writing Z = Y ÷ $817.5 million. We write

$$\$1700 \text{ million} + Y = Y \times \$2935 \text{ million} \div \$817.5 \text{ million}$$
$$\$1700 \text{ million} \times \$817.5 \text{ million} = Y \times \$2117.5 \text{ million}$$
$$Y = \$1700 \text{ million} \times \$817.5 \text{ million} \div \$2117.5 \text{ million}$$

Let us stop here. The algebra is straightforward. Our goal is to derive an equation that we can write down from intuition alone. We turn now to the intuition.

INTUITION

Consider year 20X9. The adjusted premium is $400 million. By 12 months from the inception of the accident year, 30% of the adjusted premium, or $120 million, has been processed into reported losses. The other 70% of the adjusted premium, or $280 million, has not yet been processed into reported losses.

The word "processed" warrants explanation. The adjusted premium does not *become* reported losses. Rather, think of the verb "process" as connoting emergence or development or settlement. We need a general term that denotes the relationship between the premium collected and the loss activity.

There is some relationship between the $400 million of premium and the ultimate reported losses. We don't know this relationship, since we don't know the expected loss ratio and we don't know the level of premium adequacy. We know only that at 12 months of development, 30% of the losses should have been reported. $120 million of premium has the same relationship to the losses that have already been reported as the other $280 million of premium has to the losses that are yet to be reported.

The reader might think: "We have solved the reserving problem." The relationship is the same for the $120 million of premium that has already been processed as for the $280 million of premium that has yet to be processed. The $120 million of premium that has already been processed corresponds to $75 million of reported losses. We form the equation

$120 million : $75 million :: $280 million : X

We solve for X, the bulk reserve, as X = $75 million x $280 million / $120 million, or X = $175 million.

That is not right. The logic makes sense; it is the logic of the chain ladder loss development technique. We can see this in two ways.

1. Using this logic, the bulk reserve is directly dependent on the losses that have been reported so far. If the reported losses at 12 months were twice as high ($150 million instead of $75 million), the bulk reserve would be twice as large. We verify this by writing

   $120 million : $150 million :: $280 million : X
   X = $350 million.

2. If this is the chain ladder loss development procedure, there must be a loss development factor hidden here somewhere. We solved for X in the previous equation as X = $175

million. This says that X = bulk loss reserves =

reported losses × expected losses unreported / expected losses already reported
= reported losses × (1 – loss lag) / (loss lag).

The loss lag is the reciprocal of the loss development factor. We rewrite the expression above:

(1 – loss lag) / (loss lag) = (1 – 1/LDF) / (1/LDF) = LDF – 1.

For the chain ladder reserving method, the reported losses times (LDF – 1) equals the bulk loss reserve.

This is the result that we are trying to avoid. Losses are volatile, and we don't want to give too much credence to the $75 million of losses that have been reported as of 12 months for accident year 20X9.

ACTUARIAL PRESENT VALUES

We would like to use all the available data by combining the various accident years. We can not add dollars from two different years, since a dollar from year X is worth more than a dollar from year X+1 when the inflation rate is positive.

We can add present values of dollars if the dollars have been discounted or accumulated to the same date. If we know the present value of 20X1 premiums as of a given date and the present value of 20X2 premiums as of the same date, we can add them to get the present value of the combined premiums as of that date.

It seems as though we need the present values of the premiums and losses to add figures from different years. We don't have these present values. In fact, we can't possibly have these present values, since the premiums for a given accident year may be paid at different times. Similarly, the losses for a given accident year may be paid at different times.

But we don't need the present values. We are comparing premiums to losses. We require only that the change in premiums from year to year should equal the change in expected losses from year to year. Two conditions suffice for this:

i. The expense ratio stays constant from year to year, and
ii. The premiums are at the same level of adequacy from year to year.

The premium adjustment ensures the same adequacy level from year to year. The constancy of the expense ratio is less critical. Expense ratios don't change much from year to year, and we assume that they stay constant. A significant change in expense ratios would necessitate additional premium adjustments. Such changes are not common.

We said above that "we don't need present values." Perhaps that is an overstatement. We might rephrase this to say that

> *since we are comparing premiums to losses, we can get away with adding nominal amounts from different years. We are not adding apples and oranges; we are adding golden delicious apples with McIntosh apples. It's not perfect, but it's the best we can do. The cost of getting present values is greater than the improved accuracy we might obtain.*

COMBINING YEARS

We combine the processed premium from each year, and we combine the reported losses from each year.

A. For accident year 20X9, \$120 million of premium (30% × \$400 million) has been processed so far, and \$75 million of losses have been reported.
B. For accident year 20X8, \$187.5 million of premium (50% × \$375 million) has been processed so far, and \$185 million of losses have been reported.

We do this for all ten accident years. The total processed premium is \$2117.5 million. The total reported losses are \$1700 million. The total premium that remains to be processed is \$817.5 million. We form the equation

\$2117.5 million : \$1700 million :: \$817.5 million : X

We solve for X, the total bulk reserve, as X = \$1700 × \$817.5 ÷ \$2117.5 = \$656.3 million. This is the equation that we derived earlier using the Bornhuetter-Ferguson method.

ILLUSTRATION: BASIC FORMULA

Additional examples are helpful to the practicing actuary. We provide a few further illustrations before proceeding. We estimate the IBNR from the figures below.

Calendar/ Accident Year	Adjusted Earned Premium	Aggregate Reported Loss	Aggregate Reported Loss Lag
1993	200	150	75%
1994	250	200	67%
1995	300	100	40%
1996	350	50	10%
Total	1,100	500	

Intuition

From the loss lags and the reported losses, we compute the premium that has already been processed for each accident year and the premium that has not yet been processed.

(1)	(2)	(3)	(4)	(5)	(6)
Calendar/ Accident Year	Adjusted Earned Premium	Aggregate Reported Loss	Aggregate Reported Loss Lag	Processed Premium (2) × (4)	Remaining Premium (2) × [1−(4)]
1993	200	150	75%	150.0	50.0
1994	250	200	67%	167.5	82.5
1995	300	100	40%	120.0	180.0
1996	350	50	10%	35.0	315.0
Total	1,100	*500*		*472.5*	*627.5*

We use the entries from the "total" line shown in italics. If Y = the bulk reserve, we have

$$500 : Y :: 472.5 : 627.5$$
$$\text{or } Y = 500 \times 627.5 \div 472.5 = 664.$$

Algebra

The Stanard-Bühlmann method is a Bornhuetter-Ferguson method where the expected loss ratio is derived from the observed data. We show the relationship of the two methods.

The Bornhuetter-Ferguson factors equal "1 – the loss lag" or [1 – (4)] in the table above. The bulk reserve for each year is the expected total losses times the Bornhuetter-Ferguson factor.

Since the adjusted premiums are at the same adequacy level, the adjusted premium times a constant equals the expected losses in each year. We denote this constant as "ELR."

The bulk reserve for year 1993 using the Bornhuetter-Ferguson method equals

$$\$200 \times [1 - 75\%] \times ELR.$$

We form a similar equation for all the years in the historical period. The total bulk reserve for all years combined is \$627.5 × ELR.

The total reported losses are \$500. The total incurred losses equal \$500 + \$627.5 × ELR. The ELR is the total incurred losses divided by the total adjusted premium, or

$$[\$500 + \$627.5 \times ELR] \div \$1100 = ELR.$$
$$\$500 = \$472.5 \times ELR$$
$$ELR = \$500 \div \$472.5$$

Since the bulk reserve equals \$627.5 × ELR, we have

$$bulk\ reserve = \$500 \times \$627.5 \div \$472.5 = \$664.$$

VOLATILE LOSSES

We estimate the IBNR loss reserve using the figures below.

Cal./Acc. Year	Adjusted Earned Premium	Aggregate Reported Loss	Aggregate Reported Loss Lag
1993	10,000	1,000	95%
1994	10,000	6,000	85%
1995	10,000	5,000	70%
1996	10,000	5,000	50%
1997	10,000	4,000	30%

Reported Losses vs. Expected Losses

The Stanard-Bühlmann technique is most useful when losses are highly volatile and we don't have a good feel for the expected loss ratio.

- For 1997, adjusted premiums are $10,000, and $4,000 of losses have been reported.
- For 1993, adjusted premiums are $10,000, and $1,000 of losses have been reported.

At the current valuation date, the loss lags suggest a 95% to 30% reporting ratio for 1993 compared with 1997. The observed reporting ratio is 1 to 4.

(1)	(2)	(3)	(4)	(5)	(6)
Cal./Acc. Year	Adjusted Earned Premium	Aggregate Reported Loss	Aggregate Reported Loss Lag	Processed Premium (2) × (4)	Remaining Premium (2) × [1−(4)]
1993	10,000	1,000	95%	9,500	500
1994	10,000	6,000	85%	8,500	1,500
1995	10,000	5,000	70%	7,000	3,000
1996	10,000	5,000	50%	5,000	5,000
1997	10,000	4,000	30%	3,000	7,000
Total	50,000	21,000		33,000	17,000

Letting Y = the bulk loss reserve, we have

$$21{,}000 : Y :: 33{,}000 : 17{,}000$$
$$Y = 10{,}818$$

IBNR RESERVES

We determine the IBNR reserves from the following data:

Accident Year	Adjusted Earned Premium	Incurred Losses December 31, 2000
1998	$25,781	$16,500
1999	$28,125	$9,000
2000	$30,469	$3,900

Age (months)	Percent Reported
12	16.0%
24	40.0%
36	80.0%
48	100.0%

Processing Ratio

(1)	(2)	(3)	(4)	(5)	(6)
Cal./Acc. Year	Adjusted Earned Premium	Aggregate Reported Loss	Aggregate Reported Loss Lag	Processed Premium (2) × (4)	Remaining Premium (2) × [1−(4)]
1998	$25,781	$16,500	80%	$20,624.80	$5,156.20
1999	$28,125	$9,000	40%	$11,250.00	$16,875.00
2000	$30,469	$3,900	16%	$4,875.04	$25,593.96
Total	$84,375	$29,400		$36,742.84	$47,617.16

Letting Y = the bulk loss reserve, we have

$$\$47{,}617.16 : Y :: \$36{,}742.84 : \$29{,}400$$
$$Y = \$38{,}101.15$$

WEIGHTED VS. UNWEIGHTED AVERAGES

We said above that using nominal values instead of present values is like mixing golden delicious apples with McIntosh apples. We explain what we mean by this.

Suppose we are determining age-to-age factors (link ratios) from three years of experience. Should we use the simple average of the three years or should we use a weighted average? The weights for the weighted average are normally the loss amounts at the earlier of the two valuations, though we might also use the premium volume for the three experience years. The weighted average gives more weight to the years with a greater volume of experience. The unweighted average gives equal weight to all years.

This question has baffled generations of reserve actuaries, though the answer (in most cases) is not difficult.

1. A more recent year is a better predictor of future experience than a less recent year. Mahler [1990] refers to this as "shifting risk parameters." He shows the implications for ratemaking and for experience rating; the same logic applies to reserving. The more recent accident years should receive more weight than the older accident years. This is particularly important when potential trends appear in the columns of age-to-age factors.

   The greater weight that should be assigned to more recent years does not depend on the volume of business. Our question is different. Besides the greater weight that should be applied to more recent years, should we apply greater weight to years with greater volume?

2. The answer is that we should assign weights in proportion to the real volume of business. The loss amounts in each year differ for two reasons: (i) the "real dollar" amount of losses may differ, and (ii) inflation causes the nominal amount of losses to differ even though the "real dollar" amount of losses may be the same among the years.

   Ideally, we should weight the accident years by the deflated dollar amount of losses.[7] Using deflated losses as weights is complex; the following rule is a reasonable proxy. When the dollar amount of losses is consistent with monetary inflation, we should use unweighted averages. When the dollar amount of losses is considerably different from monetary inflation, we should use weighted averages.

---

[7] Ideally, we should perform the entire reserve analysis using deflated losses, to avoid distortions caused by varying inflation rates. For a complete discussion, see Hodes, Feldblum, and Blumsohn [1999].

Adjusted Premiums

We have not yet discussed the premium adjustments. The premium adjustments depend on the type of loss data. If we use reported losses or paid losses, we use one type of adjustment. If we use reported claims or paid claims, the adjustment is different.

Before stating the general rule, we provide a set of illustrations. Each illustration is so simple that the adjustment is trivial. The series of illustrations covers all the relevant scenarios.

ILLUSTRATION #1: RATE CHANGE

> We have two accident years, 20X1 and 20X2. There is no expected loss trend; that is, the loss trend is 0% per annum.
>
> Earned premium is $100 million in 20X1 and $120 million in 20X2. All policies are effective on January 1. On January 1, 20X2, there was a +10% rate change. The exposure base is not inflation sensitive.
>
> We adjust the 20X1 and 20X2 earned premiums to the same adequacy level for a Stanard-Bühlmann procedure dealing with reported losses or paid losses.

This scenario has no loss trend: neither a loss severity trend nor a loss frequency trend. We took a +10% rate change on January 1, 20X2.

We can conceive of this in various ways:

1. The 20X1 premiums are exactly adequate. If so, the 20X2 premiums are 10% redundant. To bring the premiums to the same adequacy level for the two years, we divide the 20X2 premiums by 1.100.

2. The 20X2 premiums are exactly adequate. If so, the 20X1 premiums are deficient by a factor of 1 ÷ 1.100. To bring the premiums to the same adequacy level for the two years, we multiply the 20X1 premiums by 1.100.

   These two scenarios give the same result in the Stanard-Bühlmann technique. Multiplying the numerator of a ratio by a constant has the same effect as dividing the denominator of the ratio by the same constant.

3. There are a variety of other possibilities. The 20X1 premiums might be deficient by 5%,

or by 15%, or they might be redundant by 5%, or by 15%. They all lead to the same Stanard-Bühlmann result.

Given the various possibilities, which should we choose? The actuarial convention is to leave the most recent year unadjusted and to adjust prior years to the level of the most recent year.

This is a general actuarial convention, with the following rationale. The readers of the reserving actuary's report may not understand the Stanard-Bühlmann technique. In most situations, other company personnel believe that the current year is "correct." It is easier to explain an adjustment of prior years to the adequacy level of the current year than to explain an adjustment of the current year to the adequacy level of past years.

Thus, we multiply the 20X1 premium by 1 plus the January 1, 20X2, rate change amount.

We said above that "these two scenarios give the same result in the Stanard-Bühlmann technique." We show this explicitly.

We said earlier that if all premiums are at the same adequacy level, we can multiply all premiums by a constant "Z" to convert premiums into expected losses.

Illustration: Suppose the expected loss ratio is 70%, the 20X1 premiums are exactly adequate, and the 20X2 premiums are 10% redundant.

1. If we multiply the 20X1 premium by 1.100, the premiums in both years are 10% redundant. The value of "Z" is 70% / 1.100. In combination, we have multiplied the 20X1 premium by 1.100 × 70% / 1.100 = 70%. We have multiplied the 20X2 premium by 70% / 1.100.

2. If we divide the 20X2 premium by 1.100, the premiums in both years are exactly adequate. The value of "Z" is 70%. In combination, we have multiplied 20X1 premium by 70%. We have multiplied the 20X2 premium by 70% / 1.100.

We get the same result in both cases. This is true for all scenarios.

ILLUSTRATION #2: LOSS TRENDS

We assume a loss severity trend of +10% per annum, and we eliminate the rate change.

> We have two accident years, 20X1 and 20X2. The loss severity trend is +10% per annum. The claim frequency per exposure unit is the same in both years, though the number of exposure units may be different.
>
> Earned premium is$100 million in 20X1 and $120 million in 20X2. All policies are effective on January 1. There have been no rate changes, and the exposure base is not inflation sensitive.
>
> We adjust the 20X1 and 20X2 earned premiums to the same adequacy level for a Stanard-Bühlmann procedure dealing with reported losses or paid losses.

Let us review the possible scenarios.

A. The 20X1 premium is exactly adequate. Since losses increased by 10% per exposure unit in 20X2 and there was no rate change, the 20X2 premiums are deficient by 10%. We must multiply the 20X2 premiums by 1.100 to bring them to an adequate level.

B. The 20X2 premium is exactly adequate. Since the 20X1 losses were 9.09% [= 1 – (1 ÷ 1.100.)] less per exposure unit, and there was no rate change between the two years, the 20X1 premiums were redundant. We must divide the 20X1 premiums by 1.100 to bring them to an adequate level.

C. We can use any premium adequacy level we desire; there is no difference in the Stanard-Bühlmann result. By convention, we keep the premiums the same in the most recent year. We adjust other premiums to the adequacy level of the most recent year.

This example assumes that we are dealing with reported losses or paid losses, which are affected by both frequency and severity trends. When we deal with reported claims or paid claims, we must differentiate between the loss severity trend and the loss frequency trend.

The general rule: we determine the loss cost trend factors to bring prior years' losses to the level of the most recent year. We *divide* the prior years' premiums by the trend factors.

ILLUSTRATION #3: RATE CHANGES AND LOSS TRENDS

We assume both a loss severity trend of +10% per annum and a rate change of +10% on January 1, 20X2.

We have two accident years, 20X1 and 20X2. The loss severity trend is +10% per annum. The claim frequency per exposure unit is the same in both years, though the number of exposure units may be different. Earned premium is$100 million in 20X1 and $120 million in 20X2. All policies are effective on January 1. We took a rate change of +10% on January 1, 20X2. The exposure base is not inflation sensitive. We adjust the 20X1 and 20X2 earned premiums to the same adequacy level for a Stanard-Bühlmann procedure dealing with reported losses or paid losses.

We skip the scenarios, since the illustration is straightforward. Losses went up by 10% between the two years and the premium per exposure unit went up 10% between the two years. The premiums are at the same adequacy level. They might both be exactly adequate; they might both be deficient; they might both be redundant.

We can use the general rules that we stated above. We multiply the 20X1 premium by 1.100 for the rate change, and we divide the 20X1 premium by 1.100 for the loss trend. The net adjustment is no change.

Illustration #4: Exposure Trends

We add an exposure trend.

We have two accident years, 20X1 and 20X2. The loss severity trend is +10% per annum. Earned premium is$100 million in 20X1 and $120 million in 20X2. All policies are effective on January 1. We took a rate change of +10% on January 1, 20X2. The exposure base is inflation sensitive, and the exposure trend is 10% per annum. We adjust the 20X1 and 20X2 earned premiums to the same adequacy level for a Stanard-Bühlmann procedure dealing with reported losses or paid losses.

The exposure trend of +10% per annum exactly offsets the loss cost trend of +10% per annum. We conceive of an exposure trend as the reciprocal of a loss cost trend. The net trend is 0% per annum. This illustration is the same as the first illustration.

THE GENERAL RULES

Premiums: We bring all premiums to the current rate level. The illustrations above have policies effective on January 1 and rate changes effective on January 1. That is not necessary. Rather, we determine calendar year on-level factors to bring the earned premium in each calendar year to the current rate level.

Suppose the years in the experience period run from January 1 to December 31, and we took a rate change on July 1 of the most recent experience year.

> We have two accident years, 20X1 and 20X2. The loss severity trend is 0% per annum.
>
> Earned premium is$100 million in 20X1 and $120 million in 20X2. Policies are written evenly through the year. We took a rate change of +10% on July 1, 20X1. The exposure base is not inflation sensitive.
>
> We adjust the 20X1 and 20X2 earned premiums to the same adequacy level for a Stanard-Bühlmann procedure dealing with reported losses or paid losses.

The calendar year on-level factors are 1.075 for 20X1 and 1.025 for 20X2. We multiply the 20X1 premium by 1.075 and the 20X2 premium by 1.025.

The Stanard-Bühlmann technique is commonly used by reinsurance actuaries. Most excess-of-loss reinsurance treaties are effective on January 1, and reinsurance rate changes are effective on January 1 as well. This eases the required calculations.[8]

Losses: We want to trend all losses to a common date with the net trend factors. The net trend equals the loss frequency trend × the loss severity trend ÷ the exposure trend. However, we adjust the premiums, not the losses. Therefore, after determining the net trend factors to apply to the losses, we *divide* the premiums by these net trend factors.

---

[8] The underlying policies written by the ceding company may be written evenly during the year, and the ceding company's rate changes may have occurred during the year. The on-level factors are taken into account to determine the reinsurance rate changes; they need not be recomputed for the reserve estimate.

Claim Counts

The Stanard-Bühlmann technique can be used with reported claims in place of reported losses. It can also be used with paid claims, though the use of paid claims for reinsurance reserving is less common than the use of reported claims.

Let us first understand why we would use claim counts instead of loss dollars. Suppose a line of business has claims that are reported quickly but claim severities that are highly variable and that may remain uncertain for many years. The reserving actuary may project ultimate claims by a development procedure and the average claim severity by a trend procedure.

Illustration: A severe workers' compensation permanent disability claim is reported quickly, though it may take years before the severity of the injury is clear. The claims are paid over the remaining lifetime of the injured worker. Both the indemnity (loss of income) benefits and the medical benefits extend over decades, and they are difficult to estimate.

The reserving actuary may project ultimate claim counts by a development year procedure and ultimate claim severities by an accident year trend. Suppose we are estimating accident year 20X9 workers' compensation reserves for permanent disability claims. Within a year or two after the expiration of the 20X9 accident year, we have a preliminary estimate of the ultimate claim count.[9] Since we have only a year or two of payments on these claims – each of which may extend for 20 or 30 years – we can not estimate claim severities from the 20X9 data.

Instead, we estimate ultimate claim severities for the more mature accident years, such as 20X0 through 20X7. We use the workers' compensation loss cost trend factors derived from shorter-term injuries to extend the claim severity trend through 20X9.

This procedure is particularly well suited for workers' compensation excess-of-loss reinsurance reserving, since most of the claims are permanent injuries.

---

[9] A common reserving procedure for these claims is to project the future permanent disability claims as a percentage of the reported total indemnity claims, or as a percentage of the reported back injury claims.

Reported and Unreported Claims

When we deal with reported losses, the fundamental equation is

processed premium : unprocessed premium :: reported losses : unreported losses.

The unreported losses are the bulk reserve. When we deal with reported claims, the corresponding equation is

processed premium : unprocessed premium :: reported claims : unreported claims.

The mathematics is the same, with one difference in the premium adjustments. We explain by means of an illustration.

ILLUSTRATION #5: CLAIM FREQUENCIES

We have two accident years, 20X1 and 20X2. The loss severity trend is +10% per annum. The claim frequency per exposure unit is the same in both years, though the number of exposure units may change. Earned premium is $100 million in 20X1 and $120 million in 20X2. All policies are effective on January 1. There have been no rate changes, and the exposure base is not inflation sensitive. We are using the Stanard-Bühlmann technique to estimate ultimate claim frequencies. We adjust the 20X1 and 20X2 earned premiums to the same adequacy level.

The term "same adequacy level" requires explanation. We normally speak of premium adequacy with respect to dollars of loss, not with respect to claim counts.

Conceive of the level of premium adequacy with respect to claim counts as the claim frequency with respect to premiums. If the expected claim frequency is 100 claims for each $1 million of premium in 20X1, then 20X2 has the same level of premium adequacy if the expected claim frequency is still 100 claims for each $1 million of premium.

In the illustration above, there were no rate changes in 20X1 or 20X2, and there were no changes in claim frequency. The premiums in 20X1 and 20X2 are at the same level of premium adequacy with respect to claim frequency.

Since the average loss severity rose by 10% from 20X1 to 20X2, the premiums in the two years are not at the same level of adequacy with respect to losses. For the Stanard-Bühlmann method, we use a premium adjustment if we are dealing with reported losses. We make no premium adjustment in this case if we are dealing with reported claims.

ILLUSTRATION #6: FREQUENCY AND SEVERITY TRENDS

> We have two accident years, 20X1 and 20X2. The loss cost trend is +10% per annum, consisting of 7.8% claim severity trend and a 2.0% claim frequency trend.
>
> Earned premium is$100 million in 20X1 and $120 million in 20X2. All policies are effective on January 1. There have been no rate changes, and the exposure base is not inflation sensitive.
>
> We are using the Stanard-Bühlmann technique to estimate both ultimate losses and ultimate claim frequencies. We adjust the 20X1 and 20X2 earned premiums to the same adequacy level.

To estimate ultimate losses, we use the total loss cost trend of +10% per annum. To estimate ultimate claim counts, we use the claim frequency trend of 2.0% per annum.

Pricing actuaries have learned to be wary of claim frequency trends. In most lines of business, claim frequency does not follow simple exponential growth patterns. Econometric modeling of claim frequency has generally been disappointing. One might wonder how useful the claim frequency trends would be for the Stanard-Bühlmann reserving technique.

The pricing actuary and the reserving actuary use the trend factors for different purposes. The pricing actuary is projecting future claim frequency; most trend estimates have been poor predictors. The reserving actuary is quantifying the change between two past years. The claim frequency is a historical figure; it is not better or worse than the historical loss cost trend.

THE GENERAL RULE

The general rule for claim counts is similar to the rule for dollars of loss, with one difference. When we deal with claim counts, we adjust only for claim frequency trends, not for claim severity trends.

1. If we are given both claim frequency trends and claim severity trends, we use the product of these trends when we deal with dollars of loss. When we deal with claim counts, we use only the claim frequency trends.

2. If we have a single loss cost trend, we must use the claim frequency portion of the trend. We do not always know the claim frequency portion. If we can estimate the claim severity portion from other indices, we can "back out" the claim severity portion to derive the claim frequency portion.

3. The loss frequency trends in the historical data may reflect shifts in the mix of business, not real changes in claim frequency. Such trends may not be used in pricing, though they may be appropriate for aggregate reserving analyses.

4. For some lines of business, the exposure trends offset the loss severity trends, and the net trend is not material. When we are dealing with claim counts, we ignore loss severity trends but we still include exposure trends to calculate the premium adjustments.

   Illustration: Payroll in 20X1 is $100 million. The workers' compensation premium rate is 2% of payroll, giving a premium of $2 million. The real activity at the insured's workplace stays the same for 20X2, but wage inflation is 10% per annum, so payroll is $110 million and the workers' compensation premium is $2.2 million. Nothing has changed in the physical plant, and we expect the same number of claims. We increase the 20X1 premiums by a factor of +10% to bring them to the adequacy level of the 20X2 premiums.

Illustration: Reported Claims

We illustrate the premium adjustments by calculating the IBNR claim count from the figures below. All policies have effective dates of January 1; all rate changes occur on January 1.

Cal/Acc Year	Earned Risk Pure Premium (000)	Estimated Claim Report Lag	Reported Claims @ 12/31/91
1987	$40,000	38.0%	9
1988	$44,000	28.0	8
1989	$40,000	18.0	8
1990	$45,000	9.0	5
1991	$50,000	2.0	1

Annual loss trends and rate changes are shown below. There is no exposure trend.

Loss Cost Trends		Rate Changes	
1986 to 1987	15.0%	1/1/87	30.0%
1987 to 1988	12.5	1/1/88	10.0%
1988 to 1989	10.0	1/1/89	–10.0%
1989 to 1990	10.0	1/1/90	0.0%
1990 to 1991	10.0	1/1/91	5.0%

Premium Adjustments

There are two premium adjustments.

- We bring all premiums to the same rate level.
- We divide by the factors needed to bring all claim counts to the same claim level.

The rate change effective on January 1, 1987 is not relevant, since it affects all year equally. Conceive of the 1987 rate level as the base rate level, or 1.000. We use the other rate changes to bring premiums to the current rate level.

We can ignore the January 1, 1987, rate change only because all policies are effective on January 1. If we had any other distribution of policy effective dates during the year, we would have to consider the January 1, 1987, rate change as well.

Date	Rate Change	Rate Level Index	On-Level Factor
1/1/87	30.0%	1.0000	1.0395
1/1/88	10.0%	1.1000	0.9450
1/1/89	−10.0%	0.9900	1.0500
1/1/90	0.0%	0.9900	1.0500
1/1/91	5.0%	1.0395	1.0000

The rate level index is the cumulative downward product of the rate changes. If the policy effective dates are distributed through the year and the rate changes occur on different dates, the rate level index is the average rate level during the year. We set the rate level index for 1987 to unity. The on-level factor is the current rate level index divided by the rate level index for the accident year under consideration.

We multiply the earned risk pure premiums by the on-level factors to put all premiums on the same adequacy level.

We are given loss cost trends with no division into frequency and severity components. We assume that the trends reflect loss severity, and that the claim frequency trend is not material. No adjustment is made to premiums for trend.

Cal/Acc Year	Earned Risk Pure Premium (000)	Premium On-Level Factor	Adjusted Earned Premium
1987	$40,000	1.0395	$41,580
1988	$44,000	0.9450	$41,580
1989	$40,000	1.0500	$42,000
1990	$45,000	1.0500	$47,250
1991	$50,000	1.0000	$50,000

31 claims are reported by December 31, 1991. We determine the total processed premium and the total unprocessed premium.

Cal/Acc Year	Estimated Report Lag	Processed Premium @ 12/31/91	Unprocessed Premium @ 12/31/91
1987	38.0%	$15,800.40	$25,779.60
1988	28.0	$11,642.40	$29,937.60
1989	18.0	$7,560.00	$34,440.00
1990	9.0	$4,252.50	$42,997.50
1991	2.0	$1,000.00	$49,000.00
Total		$40,255.30	$182,154.70

The claims expected to emerge in the future, Y, is computed as

$$\$40{,}255.30 : \$182{,}154.70 :: 31 : Y,$$
$$\text{or } Y = 140$$

The reserve indication is for five accident years only. For the oldest year in the experience period, only 38% of claims have been reported so far. We still expect much claim emergence for prior years. We are using a frequency-severity reserving procedure for the more recent accident years, where the reported claim severities are not credible. For previous years, we use other reserving techniques.

For accident years 1987 through 1991, the reserve indication has great uncertainty. From 31 claims that have been reported so far, we are estimating future emergence of 140 claims.

The volatility of the reported claim counts can be seen by a comparison of accident years 1987 and 1989. As of December 31, 1991, the processed adjusted premium for 1987 is $15,800 and 9 claims have been reported, while the processed adjusted premium for 1989 is $7,560 and 8 claims have been reported.

Loss Cost Trends

Let us revise the scenario to incorporate the loss cost trends. If we use the Stanard-Bühlmann technique to estimate dollars of losses, what are the adjusted premiums?

We form an index of relative loss costs, using 1987 as the base year. We ignore the loss trend from 1986 to 1987, since it affects all years equally. The index value for 1987 is unity, the index value for 1988 is 1.125, and so forth. The trend factor is the index value for the most recent year divided by the index value for the year under consideration.

Were we adjusting losses to the current level, we would multiply by these trend factors. Since we are adjusting premiums, we divide by these trend factors.

Period	Loss Trend	Index Value	Trend Factor
1986 to 1987	15.0%	1.0000	1.497
1987 to 1988	12.5	1.1250	1.331
1988 to 1989	10.0	1.2375	1.210
1989 to 1990	10.0	1.3613	1.100
1990 to 1991	10.0	1.4974	1.000

CALENDAR YEAR EMERGENCE

The reserving actuary is often asked to show the expected emergence and payment of losses by development period (i.e., by calendar year) subsequent to the valuation date. The emergence and payment patterns have several uses.

1. *Reserving:* The expected loss emergence and loss payment in the next calendar period provides a check on the accuracy of the reserve indication. The reserve indication itself is difficult to judge, since the losses may not emerge or settle for many years. By comparing the actual emergence or settlement in the next calendar quarter or year with the estimates implied by the reserving procedure, the company gets a better feel for the accuracy and the bias inherent in the reserve estimate.

2. *Investments:* The expected emergence and settlement of claims is necessary for asset liability management. The insurer's investment department seeks expected liability cash flows in the coming months to optimize its investment strategy. Many insurers structure their investment portfolio in accordance with their insurance liabilities, selecting security types, fixed-income durations, and investment quality to best manage their overall risk. The reserving actuary provides the settlement patterns for the loss reserve portfolio.

PRINCIPLES OF EMERGENCE

We have examined so far the future emergence of losses, or the bulk reserve, and the future payment of losses, or the total (case + bulk) reserve. We now consider the emergence or payment of losses by development period.

- The bulk reserve as of December 31, 20XX, equals the losses expected to emerge in calendar years 20XX+1 and subsequent for accident years 20XX and prior.
- The expected emergence in 20XX+1 equals the losses expected to emerge in calendar years 20XX+1 *only* for accident years 20XX and prior.

We illustration the method using the example directly above. We calculate the number of claims expected to emerge for accident years 1988 through 1991 during calendar year 1992.

We estimate the amount of adjusted premium that will be processed in 1992. For any accident year "X," the adjusted premium that will be processed in 1992 is the total adjusted premium for that accident year times the difference in the claim report lag between that accident year and the previous accident year.

Cal/Acc Year	Adjusted Earned Premium	Estimated Report Lag	Premium Processed in 1992 (000)
1987	$41,580	38.0%	—
1988	$41,580	28.0	$4,158
1989	$42,000	18.0	$4,200
1990	$47,250	9.0	$4,253
1991	$50,000	2.0	$3,500
1988-1991			$16,111

For instance, the 1988 adjusted premium that will be processed in 1992 equals

$$\$41,580 \times (38.0\% - 28.0\%) = \$4,158.$$

The total adjusted premium for accident years 1988 through 1991 that will be processed in 1992 equals $16,111. We form the standard equation as

$$\$40,255.30 : \$16,111 :: 31 : Y,$$
$$\text{or } Y = 12.4 \text{ claims.}$$

SUMMARY

The Stanard-Bühlmann reserving technique is a simple, intuitive procedure that combines the chain ladder loss development method with the expected loss method. It works well even in situations that don't lend themselves to easy estimates, such as reserving for high layers of loss. The Stanard-Bühlmann technique has been adopted by many reinsurance actuaries. This practitioners' guide should encourage its use by primary company actuaries as well.