# CHAPTER 9 – BORNHUETTER-FERGUSON TECHNIQUE

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

In the 1993 paper "Loss Development Using Credibility,"[53] Eric Brosius described the Bornhuetter-Ferguson method as a credibility weighting between the development method and the expected claims method. In the development method, full credibility (i.e., $Z = 1$) is given to actual claims experience; and in the expected claims method, no credibility (i.e., $Z = 0$) is given to actual claims. In the Bornhuetter-Ferguson, credibility is equal to the percentage of claims developed at a particular stage of maturity, which is a function of the cumulative claim development factor (i.e., $Z = 1.00$ / cumulative development factor). Therefore, more weight is given to the expected claims method in less mature years, and more weight is given to the development method in more mature years of the experience period.

## Key Assumptions

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

The reporting and payment patterns used in the Bornhuetter-Ferguson methods are the same as those selected in the development method. However, the application of the development factors differs between the two methods. It is also important to note that the expected claims used in the Bornhuetter-Ferguson method using reported claims are the same as those used in the Bornhuetter-Ferguson method using paid claims.

## Common Uses of the Bornhuetter-Ferguson Technique

The Bornhuetter-Ferguson technique is most frequently applied to reported and paid claims, yet it can also be used with the number of claims and with ALAE. Actuaries use this technique with all lines of insurance including short-tail lines and long-tail lines. Similar to the development

[53] *CAS Study Note*, 1993

method, the Bornhuetter-Ferguson method is used with data organized in many different time intervals including:

— Accident year
— Policy year
— Underwriting year
— Report year
— Fiscal year

Actuaries also apply this technique to data organized by month, quarter, or half-year.

## Mechanics of the Bornhuetter-Ferguson Technique

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

Ultimate Claims = Actual Reported Claims + Expected Unreported Claims
Ultimate Claims = Actual Reported Claims + (Expected Claims) x (% Unreported)

Ultimate Claims = Actual Paid Claims + Expected Unpaid Claims
Ultimate Claims = Actual Paid Claims + (Expected Claims) x (% Unpaid)

Since actual reported and paid claims are both known quantities, the challenge of the Bornhuetter-Ferguson method is to calculate the expected unreported and expected unpaid claims. In order to complete the Bornhuetter-Ferguson method, the actuary must select claim development patterns and develop an expected claims estimate.

In our step-by-step example of the Bornhuetter-Ferguson method, we use the cumulative claim development patterns presented in Chapter 7 and the expected claims developed in Chapter 8.[54] In Exhibit I, Sheet 1, we present both the reported and paid Bornhuetter-Ferguson projections for U.S. Industry Auto.

The second column of Exhibit I, Sheet 1, contains the expected claims developed in Chapter 8 for U.S. Industry Auto. Columns (3) and (4) are the selected cumulative claim development factors described in Chapter 7. We convert the cumulative claim development patterns to percentage unreported and percentage unpaid in Columns (5) and (6), respectively. The percentage reported is equal to the inverse of the cumulative reported claim development factor. Thus, the percentage unreported is equal to 1.00 minus the inverse of the cumulative reported claim development factor. Similarly, the percentage paid is equal to the inverse of the cumulative paid claim

[54] Recall that expected claims are developed in Chapter 8 based on earned premiums and selected claim ratios. We discussed the importance of adjusting premiums to an on-level basis when selecting expected claim ratios. The purpose of adjusting premiums to an on-level basis is to develop a proxy for the underlying exposures in each year of the experience period. An alternative to the use of premiums and claim ratios for developing expected claims is exposures and pure premiums (also referred to as loss rates or loss costs). Many actuaries who work with self-insurers rely on such an approach. Due to enhancements in many insurers' data systems, historical exposures may become more readily available to actuaries and can thus be directly incorporated into the development of expected claims for the Bornhuetter-Ferguson technique.

development factor; and the percentage unpaid is equal to 1.00 minus the inverse of the cumulative paid claim development factor.

Once again, we summarize the selected claim development factors for reported and paid claims as well as the associated reporting and payment patterns in Table 1 below.

**Table 1 – U.S. Industry Auto**
**Selected Reporting and Payment Patterns**

| | Reported Claims | | | Paid Claims | | |
|---|---|---|---|---|---|---|
| **Age (Month)** | **CDF to Ultimate** | **% Reported** | **% Unreported** | **CDF to Ultimate** | **% Paid** | **% Unpaid** |
| 12 | 1.292 | 77.4% | 22.6% | 2.390 | 41.8% | 58.2% |
| 24 | 1.110 | 90.1% | 9.9% | 1.404 | 71.2% | 28.8% |
| 36 | 1.051 | 95.1% | 4.9% | 1.184 | 84.5% | 15.5% |
| 48 | 1.023 | 97.8% | 2.2% | 1.085 | 92.2% | 7.8% |
| 60 | 1.011 | 98.9% | 1.1% | 1.040 | 96.2% | 3.8% |
| 72 | 1.006 | 99.4% | 0.6% | 1.020 | 98.0% | 2.0% |
| 84 | 1.003 | 99.7% | 0.3% | 1.011 | 98.9% | 1.1% |
| 96 | 1.001 | 99.9% | 0.1% | 1.006 | 99.4% | 0.6% |
| 108 | 1.000 | 100.0% | 0.0% | 1.004 | 99.6% | 0.4% |
| 120 | 1.000 | 100.0% | 0.0% | 1.002 | 99.8% | 0.2% |

The primary assumption of the reported Bornhuetter-Ferguson method is that unreported claims will emerge in accordance with expected claims. Thus, the next step of this method is to calculate the expected unreported claims. In Column (7), we calculate expected unreported claims by accident year. Expected unreported claims are equal to expected claims in Column (2) multiplied by the percentage unreported in Column (5) for each year. Similarly, expected unpaid claims in Column (8) are equal to expected claims from Column (2) multiplied by the percentage unpaid in Column (6).

Returning to our original formulae for the Bornhuetter-Ferguson method,

Ultimate Claims = Actual Reported Claims + Expected Unreported Claims

Ultimate Claims = Actual Paid Claims + Expected Unpaid Claims

We can now calculate the projected ultimate claims. Using the reported Bornhuetter-Ferguson method, projected ultimate claims in Column (11) are equal to the actual reported claims in Column (9) plus the expected unreported claims in Column (7). The projected ultimate claims based on the paid Bornhuetter-Ferguson method are shown in Column (12); they are equal to actual paid claims in Column (10) plus expected unpaid claims in Column (8).

## Unpaid Claim Estimate Based on Bornhuetter-Ferguson Technique

We follow a similar procedure for determining the unpaid claim estimate based on the Bornhuetter-Ferguson technique (Exhibit I, Sheet 2) as presented in the prior chapters for the development and expected claims techniques. Estimated IBNR is equal to projected ultimate claims less reported claims[55] and the total unpaid claim estimate is equal to the difference between projected ultimate claims and paid claims.

Exhibit I, Sheet 2, presents the calculations of the unpaid claim estimate for U.S. Industry Auto. Columns (2) and (3) contain reported and paid claims data as of December 31, 2007. The projected ultimate claims, developed in Exhibit I, Sheet 1, are summarized in Columns (4) and (5). Case outstanding, which are equal to the difference between reported claims and paid claims as of December 31, 2007, are presented in Column (6). Estimated IBNR is equal to projected ultimate claims minus reported claims. In Columns (7) and (8), we calculate estimated IBNR based on the reported and paid Bornhuetter-Ferguson techniques, respectively. The total unpaid claim estimate is equal to the sum of case outstanding and estimated IBNR. We present the estimate of total unpaid claims in Columns (9) and (10) based on the reported and paid Bornhuetter-Ferguson techniques, respectively.

## When the Bornhuetter-Ferguson Technique Works and When it Does Not

An advantage of the Bornhuetter-Ferguson technique is that random fluctuations early in the life of an accident year (or other defined time interval) do not significantly distort the projections. For example, if several large and unusual claims are reported for an accident year, then the reported claim development technique may produce overly conservative ultimate claims estimates. This situation does not, however, seriously distort the Bornhuetter-Ferguson technique.

Actuaries frequently use the Bornhuetter-Ferguson method for long-tail lines of insurance, particularly for the most immature years, due to the highly leveraged nature of claim development factors for such lines. Actuaries may also use the Bornhuetter-Ferguson technique if the data is extremely thin or volatile or both. For example, when an insurer has recently entered a new line of business or a new territory and there is not yet a credible volume of historical claim development experience, an actuary may use the Bornhuetter-Ferguson technique. In such circumstances, the actuary would likely need to rely on benchmarks, either from similar lines at the same insurer or insurance industry experience, for development patterns and expected claim ratios (or pure premiums). (See previous comments about the use of industry benchmarks.)

In a discussion of when to use the Bornhuetter-Ferguson method in the paper “The Actuary and IBNR,” the authors state: “It can be argued that the most prudent course is, when in doubt, to use expected losses, in as much as it is certainly indicated for volatile lines, and in the case of a stable line, the expected loss ratio should be predictable enough so that both techniques produce the same result.”[56]

The Bornhuetter-Ferguson technique can be a useful method for very short-tail lines as well as long-tail lines. For very short-tail lines, the IBNR can be set equal to a multiple of the last few months’ earned premium; this is essentially an application of the Bornhuetter-Ferguson technique.

[55] Recall that the formula for the reported Bornhuetter-Ferguson method is:

Ultimate Claims = Actual Reported Claims + Expected Unreported Claims

Thus, for the reported Bornhuetter-Ferguson projection, the expected unreported claims are equal to the estimated IBNR.

[56] *PCAS*, 1972.

## The Bornhuetter-Ferguson Method and Cumulative CDFs Less than 1.00

Downward development (i.e., cumulative development factors that are less than 1.00) does occur for some insurers, for some lines of business. Automobile physical damage and property are examples of coverages in which actuaries can observe this type of development experience. For some insurers, salvage and subrogation recoveries lag the reporting and payment of claims, which can result in report-to-report factors that are less than 1.00. For some insurers, a conservative philosophy regarding case outstanding can also result in an observed downward development of reported claims as payments for claims may be less than the case outstanding set by claims adjusters. For those lines of business for which the actuary derives cumulative claim development factors that are less than 1.00, we revisit the original premise of the Bornhuetter-Ferguson method.

At the beginning of this chapter, we refer to Brosius' description of the Bornhuetter-Ferguson method as a credibility-weighting between the development method and the expected claims method. Credibility is concerned with the combination of the projections from these two methods. The basic formula for calculating the credibility-weighted projection is:

$$[(Z) \times (\text{development method})] + [(1 - Z) \times (\text{expected claims method})],$$

where,

$0 \leq Z \leq 1$,
Z is the credibility assigned to the development method, and
$(1 - Z)$ is the complement of credibility assigned to the expected claims method.

As noted earlier, the credibility is equal to the percentage of claims developed at a particular stage of maturity, which is a function of the cumulative claim development factor (Z = 1.000 / cumulative development factor).

From a theoretical perspective, the credibility-weighting approach of the Bornhuetter-Ferguson method does not hold true if the cumulative development factor is less than 1.00 since the value assigned to credibility, Z, is then greater than 1.00. For example, if the cumulative development factor is 0.93, then the credibility assigned to the development method is equal to 1.075 (1.00 / 0.93). However, as defined above, credibility must be a value between 0 and 1. Thus, a credibility value of 1.075 is outside of the acceptable range.

While cumulative development factors that are less than 1.00 present a theoretical issue for the use of the Bornhuetter-Ferguson method, in practice, many actuaries continue to use this method with such factors. One solution to address this theoretical challenge is to limit the cumulative development factors to a minimum value of 1.00 when applying the Bornhuetter-Ferguson technique. (We follow this approach for the examples in this text.) Alternatively, and what happens quite frequently in practice, is that the actuary will still calculate the reported Bornhuetter-Ferguson projected ultimate claims using cumulative development factors that are less than 1.00 but will rely on another technique to select ultimate claims for the year(s) in question (i.e., years with cumulative development factors less than 1.00). As noted previously in this chapter, actuaries frequently use the Bornhuetter-Ferguson method for long-tail lines of insurance, particularly for the most immature years. Cumulative development factors for these lines and years are typically much greater than 1.00. Nevertheless, it is worthwhile to note that some actuaries continue to include the Bornhuetter-Ferguson method as part of their analyses even in the presence of cumulative development factors that are less than 1.00.

## XYZ Insurer

In Exhibit II, Sheets 1 and 2, we present the results of the reported and paid Bornhuetter-Ferguson methods based on the expected claims developed in Chapter 8 for XYZ Insurer. The presentation and calculations are identical to the previous example for U.S. Industry Auto (Exhibit I). We will not examine the results of this projection in detail because we know that the expected claims estimates underlying the projections are likely inaccurate. Remember that the primary assumption of the development method does not hold true for XYZ Insurer as a result of the operational and environmental changes that took place during the experience period. Nevertheless, we derive the current estimates of expected claims using unadjusted reported and paid claim development methods. We compare the results of the Bornhuetter-Ferguson method with the expected claims method and the development method in Exhibit II, Sheet 3 (projected ultimate claims) and in Exhibit II, Sheet 4 (estimated IBNR). In later chapters, we look at alternative methods that can be used for developing expected claims for use in a revised Bornhuetter-Ferguson method.

## Influence of a Changing Environment on the Bornhuetter-Ferguson Method[57]

In Chapters 7 and 8, we discuss the performance of the development technique and the expected claims technique, respectively, during times of change. We continue with these examples using the Bornhuetter-Ferguson technique. Since the Bornhuetter-Ferguson method is a combination of the development method and the expected claims method, we will refer you to these prior chapters for critical input. For example, refer to Chapter 7 for the reported and paid claim development triangles and the selection of age-to-age factors, and refer to Chapter 8 for the calculation of expected claims.

### Scenario 1 – U.S. PP Auto Steady-State

For Scenarios 1 through 4, we use an expected claim ratio of 70%. Since the steady-state environment also has a 70% ultimate claim ratio, the Bornhuetter-Ferguson technique generates an accurate estimate of IBNR. We see in Chapters 7 and 8, that the development and expected claims techniques also generate accurate IBNR values in a steady-state environment. Detailed calculations are presented for the Bornhuetter-Ferguson method in the top section of Exhibit III, Sheet 1.

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[57] We present the following examples to demonstrate the effect of not changing assumptions on the resulting projections of ultimate claims and the estimate of unpaid claims. We recognize that the examples are not necessarily representative of real-life applications of the Bornhuetter-Ferguson method since we assume that there are no adjustments in expected claims in anticipation of the events that caused higher claim ratios or changes in business mix. Most insurers have a feel for whether a market is getting softer or harder, so they would have a sense as to the direction to adjust the expected claims, if not the absolute amount of adjustment. In addition, actuaries typically use the Bornhuetter-Ferguson technique where development data is sparse and erratic, which is exactly where the development approaches are very weak. Hence, we note that the PP Auto examples are biased against a Bornhuetter-Ferguson approach.

## Scenario 2 – U.S. PP Auto Increasing Claim Ratios

The weakness of the expected claims method is also a weakness of the Bornhuetter-Ferguson method. Remember the original formulae for the reported and paid Bornhuetter-Ferguson method:

Ultimate Claims = Actual Reported Claims + Expected Unreported Claims

Ultimate Claims = Actual Paid Claims + Expected Unpaid Claims

While projected ultimate claims are increasing between Scenarios 1 and 2, the increases are due to higher values of actual reported and paid claims and not higher estimates of the expected unreported and unpaid claims. Since the expected claims estimate does not change in this example, the expected unreported and unpaid claims do not change in Scenario 2 from the steady-state values of Scenario 1.

For the reported Bornhuetter-Ferguson technique, the estimated IBNR is identical between the steady-state environment and the environment with increasing claim ratios. Without a deliberate change in the expected claim ratio, this method will not respond to a situation with increasing claim ratios. The paid Bornhuetter-Ferguson performs even worse than the reported Bornhuetter-Ferguson technique for Scenario 2. The estimate of expected unpaid claims is understated to an even greater degree than the expected unreported claims. This is due to the longer-term nature of the payment pattern than the reporting pattern, which implies that the percentage unpaid cannot be less than the percentage unreported at any age. (See Table 5 of Chapter 7, which summarizes the reporting and payment patterns.)

## Scenario 3 – U.S. PP Auto Increasing Case Outstanding Strength

We present the calculations for Scenario 3 in the top section of Exhibit III, Sheet 2. The reported Bornhuetter-Ferguson technique produces an estimate of IBNR that is greater than the actual IBNR for this scenario. Similar to the paid claim development technique, the paid Bornhuetter-Ferguson method is unaffected by changes only in case outstanding strength.

In Chapter 7, we saw how increases in case outstanding strength led to increases in age-to-age factors and in cumulative claim development factors. The cumulative claim development factors are an important input to the Bornhuetter-Ferguson method. Thus, if the cumulative claim development factors are changing due to increases in case outstanding strength, it will also have an effect on the Bornhuetter-Ferguson projection. The expected claims, on the other hand, remain unchanged.

The estimated IBNR, in this scenario, based on the reported Bornhuetter-Ferguson method is greater than the actual IBNR requirement. However, the overstatement is less for the reported Bornhuetter-Ferguson method than for the reported claim development method because we did not increase the expected claims. In Chapter 7, we discuss how there are two forces that contribute to the excessive estimate of IBNR in the development technique. First, age-to-age factors increase due to the change in case outstanding adequacy. Second, we then multiply the resulting higher cumulative claim development factors by the latest valuation of reported claims, which contains higher reported values due to the increase in case outstanding strength. There is, in essence, a leveraging effect of higher factors and higher claims in the development technique. In the Bornhuetter-Ferguson method, the higher cumulative claim development factors result in greater percentages of expected unreported claims. However, the same leveraging effect does not exist since expected claims, not actual claims, are the basis for determining unreported claims in the Bornhuetter-Ferguson method, and the expected claims did not change in our example.

## Scenario 4 – U.S. PP Auto Increasing Claim Ratios and Case Outstanding Strength

We present the detailed calculations for Scenario 4 in the bottom section of Exhibit III, Sheet 2. We see that the estimated IBNR based on the reported Bornhuetter-Ferguson method is overstated while the paid Bornhuetter-Ferguson projection is understated, absent a change in the expected claims assumption.

For both projections, the expected claims used in the example are too low. This is the reason that the paid Bornhuetter-Ferguson method produces an estimate of IBNR that is $443,260 lower than the actual IBNR. This is the same difference between estimated and actual IBNR that we saw in Scenario 2, where claim ratios increased and case outstanding strength remained stable. Since the payment pattern is unaffected by changes in case outstanding adequacy, there is no effect on the paid Bornhuetter-Ferguson method. The sole reason for the inadequacy of the paid Bornhuetter-Ferguson method is the understatement of expected claims.

In Scenario 2 (increasing claim ratios and stable case outstanding strength), we see that the reported Bornhuetter-Ferguson technique produces an estimated IBNR that is lower than the actual IBNR. In Scenario 3 (stable claim ratio and increasing case outstanding strength), the estimated IBNR based on the reported Bornhuetter-Ferguson method is too high. These two factors work in opposition in Scenario 4, in which both claim ratios and case outstanding strength are increasing. Even though expected claims are too low for Scenario 4, there is more than an offsetting effect from the higher cumulative development factors leading to an estimated IBNR for the reported Bornhuetter-Ferguson technique that is $112,773 higher than the actual IBNR.

In Scenario 4, with increasing claim ratios and case outstanding strengthening, the difference from the actual IBNR using the Bornhuetter-Ferguson method could be positive or negative depending on the extent of case outstanding strengthening and deteriorating claim ratio.

## U.S. Auto Steady-State (No Change in Product Mix)

In the last two examples, we present the projections for a combined portfolio of private passenger and commercial automobile. In the top section of Exhibit IV, we summarize the calculations assuming a steady-state (i.e., no change in product mix). Similar to our projections using the claim development and expected claims techniques, we demonstrate in Exhibit IV, that the Bornhuetter-Ferguson technique will generate the correct IBNR requirement if there is no change in the product mix.

## U.S. Auto Changing Product Mix

In the final example, we assume that the volume of commercial automobile insurance is increasing at a greater rate than that of private passenger automobile insurance. In the bottom section of Exhibit IV, we quickly observe that both the reported and paid Bornhuetter-Ferguson methods produce estimated IBNR that is lower than the actual IBNR. This is due to the expected claim ratio assumption that is unchanged from the U.S. Auto Steady-State.

Since the commercial automobile segment is growing at a greater rate than the private passenger auto segment, and since commercial automobile has a higher ultimate claim ratio, the actuary needs to modify the expected claim ratio assumption. Without such modification, the estimated IBNR from both the expected claims and the Bornhuetter-Ferguson methods proves inadequate. The reporting and payment patterns also require change. With an increasing proportion of commercial automobile, the reporting and payment patterns lengthen, and thus result in the requirement for a higher IBNR value.

## Benktander Technique

An often-cited advantage of the Bornhuetter-Ferguson technique versus the development technique is stability in the presence of sparse data. However, since the estimate of unpaid claims for the most recent accident years using the Bornhuetter-Ferguson technique is heavily dependant on the actuary's judgment when determining the expected claims, actual claims emergence for these years may be ignored to some extent.

The Benktander method, introduced in 1976, is a credibility-weighted average of the Bornhuetter-Ferguson technique and the development technique. The advantage cited by the authors is that this method will prove more responsive than the Bornhuetter-Ferguson technique and more stable than the development technique. (For further information on the development of the technique and underlying proofs of the methodology, see Thomas Mack's 2000 *ASTIN Bulletin* paper "Credible Claims Reserves: The Benktander Method.")

The Benktander method is often considered an iterative Bornhuetter-Ferguson method. The only difference in the two methods is the derivation of the expected claims. As we discuss in Chapter 8 – Expected Claims Technique, most insurers use an expected claim ratio and earned premium to determine expected claims and many self-insurers use pure premiums and exposures. Such expected claims become the input for the Bornhuetter-Ferguson technique. In the Benktander technique, the expected claims are the projected ultimate claims from an initial Bornhuetter-Ferguson projection – thus, the reference to the Benktander method as an iterative Bornhuetter-Ferguson method. It is interesting to note that the Benktander projection of ultimate claims will approach the projected ultimate claims produced by the development technique after sufficient iterations. (See Thomas Mack's 2000 ASTIN paper for the detailed proof.)

In Exhibits V and VI, we present the Benktander technique using our six examples of changing environments. We follow the same exhibit format that was presented earlier in this chapter for the Bornhuetter-Ferguson technique. The only difference between the Bornhuetter-Ferguson projections in Exhibits III and IV and the Benktander projections in Exhibits V and VI are the expected claims. In the Bornhuetter-Ferguson projections, we derive the expected claims based on the initial expected claim ratio multiplied by the earned premium. In the Benktander projections, the expected claims are based on the Bornhuetter-Ferguson projections (from Exhibits III and IV).

In the following table, we summarize the differences from the true unpaid claims, in thousands of dollars, based on the Bornhuetter-Ferguson technique and the Benktander technique for the six examples related to changing environments.

| Example Name | Difference from True IBNR ($000) Using | | | |
|---|---|---|---|---|
| | Bornhuetter-Ferguson Method | | Benktander Method | |
| | Reported | Paid | Reported | Paid |
| U.S. PP Auto Steady-State | 0 | 0 | 0 | 0 |
| U.S. PP Auto Increasing Claim Ratios | 163 | 443 | 29 | 196 |
| U.S. PP Auto Increasing Case Outstanding Strength | -205 | 0 | -239 | 0 |
| U.S. PP Auto Increasing Claim Ratios and Case Outstanding Strength | -113 | 443 | -300 | 196 |
| U.S. Auto Steady-State | 0 | 0 | 0 | 0 |
| U.S. Auto Changing Product Mix | 223 | 400 | 233 | 498 |

The Benktander technique is significantly more responsive to changes in the underlying claim ratio but is less responsive to changes in the case outstanding adequacy. The Benktander technique is also less responsive to changes in the product mix than the Bornhuetter-Ferguson technique.

Note that the Benktander method always gives greater credibility to the development technique. Thus, where there are no changes in the underlying claim development patterns, we expect the Benktander method to be more responsive than the Bornhuetter-Ferguson method. Where claim development patterns are changing, the Benktander method may not produce the most appropriate estimate as seen in the examples with changing case outstanding adequacy and changes in product mix. With the changing product mix, the Benktander method would have proven responsive to the changing claim ratio but not to the changes in the underlying development patterns.

**Chapter 9 - Bornhuetter-Ferguson Technique**
**U.S. Industry Auto**
**Projection of Ultimate Claims Using Reported and Paid Claims ($000)**

Exhibit I
Sheet 1

| Accident Year | Expected Claims | CDF to Ultimate | | Percentage | | Expected Claims | | Claims at 12/31/07 | | Projected Ultimate Claims Using B-F Method with | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Reported | Paid | Unreported | Unpaid | Unreported | Unpaid | Reported | Paid | Reported | Paid |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| 1998 | 51,430,657 | 1.000 | 1.002 | 0.0% | 0.2% | 0 | 102,656 | 47,742,304 | 47,644,187 | 47,742,304 | 47,746,843 |
| 1999 | 51,408,736 | 1.000 | 1.004 | 0.0% | 0.4% | 0 | 204,816 | 51,185,767 | 51,000,534 | 51,185,767 | 51,205,350 |
| 2000 | 51,680,983 | 1.001 | 1.006 | 0.1% | 0.6% | 51,629 | 308,236 | 54,837,929 | 54,533,225 | 54,889,558 | 54,841,461 |
| 2001 | 54,408,716 | 1.003 | 1.011 | 0.3% | 1.1% | 162,738 | 591,984 | 56,299,562 | 55,878,421 | 56,462,300 | 56,470,405 |
| 2002 | 59,421,665 | 1.006 | 1.020 | 0.6% | 2.0% | 354,404 | 1,165,131 | 58,592,712 | 57,807,215 | 58,947,116 | 58,972,346 |
| 2003 | 56,318,302 | 1.011 | 1.040 | 1.1% | 3.8% | 612,761 | 2,166,089 | 57,565,344 | 55,930,654 | 58,178,105 | 58,096,743 |
| 2004 | 59,646,290 | 1.023 | 1.085 | 2.2% | 7.8% | 1,341,021 | 4,672,751 | 56,976,657 | 53,774,672 | 58,317,678 | 58,447,423 |
| 2005 | 61,174,953 | 1.051 | 1.184 | 4.9% | 15.5% | 2,968,528 | 9,506,918 | 56,786,410 | 50,644,994 | 59,754,938 | 60,151,912 |
| 2006 | 61,926,981 | 1.110 | 1.404 | 9.9% | 28.8% | 6,136,908 | 17,819,445 | 54,641,339 | 43,606,497 | 60,778,247 | 61,425,942 |
| 2007 | 61,864,556 | 1.292 | 2.390 | 22.6% | 58.2% | 13,981,773 | 35,979,805 | 48,853,563 | 27,229,969 | 62,835,336 | 63,209,774 |
| Total | 569,281,839 | | | | | 25,609,761 | 72,517,830 | 543,481,587 | 498,050,368 | 569,091,348 | 570,568,198 |

Column Notes:
(2) Developed in Chapter 8, Exhibit II, Sheet 1.
(3) and (4) Developed in Chapter 7, Exhibit I, Sheets 1 and 2.
(5) = [1.00 - (1.00 / (3))].
(6) = [1.00 - (1.00 / (4))].
(7) = [(2) x (5)].
(8) = [(2) x (6)].
(9) and (10) Based on Best's Aggregates & Averages U.S. private passenger automobile experience.
(11) = [(7) + (9)].
(12) = [(8) + (10)].

**Chapter 9 - Bornhuetter-Ferguson Technique**
**U.S. Industry Auto**
**Development of Unpaid Claim Estimate ($000)**

| Accident Year | Claims at 12/31/07 Reported | Claims at 12/31/07 Paid | Projected Ultimate Claims Using B-F Method with Reported | Projected Ultimate Claims Using B-F Method with Paid | Case Outstanding at 12/31/07 | Unpaid Claim Estimate at 12/31/07: IBNR - Based on B-F Method with Reported | Unpaid Claim Estimate at 12/31/07: IBNR - Based on B-F Method with Paid | Unpaid Claim Estimate at 12/31/07: Total - Based on B-F Method with Reported | Unpaid Claim Estimate at 12/31/07: Total - Based on B-F Method with Paid |
|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| 1998 | 47,742,304 | 47,644,187 | 47,742,304 | 47,746,843 | 98,117 | 0 | 4,539 | 98,117 | 102,656 |
| 1999 | 51,185,767 | 51,000,534 | 51,185,767 | 51,205,350 | 185,233 | 0 | 19,583 | 185,233 | 204,816 |
| 2000 | 54,837,929 | 54,533,225 | 54,889,558 | 54,841,461 | 304,704 | 51,629 | 3,532 | 356,333 | 308,236 |
| 2001 | 56,299,562 | 55,878,421 | 56,462,300 | 56,470,405 | 421,141 | 162,738 | 170,843 | 583,879 | 591,984 |
| 2002 | 58,592,712 | 57,807,215 | 58,947,116 | 58,972,346 | 785,497 | 354,404 | 379,634 | 1,139,901 | 1,165,131 |
| 2003 | 57,565,344 | 55,930,654 | 58,178,105 | 58,096,743 | 1,634,690 | 612,761 | 531,399 | 2,247,451 | 2,166,089 |
| 2004 | 56,976,657 | 53,774,672 | 58,317,678 | 58,447,423 | 3,201,985 | 1,341,021 | 1,470,766 | 4,543,006 | 4,672,751 |
| 2005 | 56,786,410 | 50,644,994 | 59,754,938 | 60,151,912 | 6,141,416 | 2,968,528 | 3,365,502 | 9,109,944 | 9,506,918 |
| 2006 | 54,641,339 | 43,606,497 | 60,778,247 | 61,425,942 | 11,034,842 | 6,136,908 | 6,784,603 | 17,171,750 | 17,819,445 |
| 2007 | 48,853,563 | 27,229,969 | 62,835,336 | 63,209,774 | 21,623,594 | 13,981,773 | 14,356,211 | 35,605,367 | 35,979,805 |
| Total | 543,481,587 | 498,050,368 | 569,091,348 | 570,568,198 | 45,431,219 | 25,609,761 | 27,086,611 | 71,040,980 | 72,517,830 |

Column Notes:
(2) and (3) Based on Best's Aggregates & Averages U.S. private passenger automobile experience.
(4) and (5) Developed in Exhibit I, Sheet 1.
(6) = [(2) - (3)].
(7) = [(4) - (2)].
(8) = [(5) - (2)].
(9) = [(6) + (7)].
(10) = [(6) + (8)].

**Chapter 9 - Bornhuetter-Ferguson Technique**
**Impact of Changing Conditions**
**U.S. PP Auto - Development of Unpaid Claim Estimate**

Exhibit III
Sheet 1

| Accident Year | Age of Accident Year at 12/31/08 | Expected Claims | Claims at 12/31/08 | | CDF to Ultimate | | Expected Percentage | | Projected Ultimate Claims Using B-F Method with | | Estimated IBNR Using B-F Method with | | Actual IBNR | Diff from Actual IBNR Using B-F Method with | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Reported | Paid | Reported | Paid | Unreported | Unpaid | Reported | Paid | Reported | Paid | | Reported | Paid |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| **Steady-State** | | | | | | | | | | | | | | | |
| 1999 | 120 | 700,000 | 700,000 | 700,000 | 1.000 | 1.000 | 0.0% | 0.0% | 700,000 | 700,000 | 0 | 0 | 0 | 0 | 0 |
| 2000 | 108 | 735,000 | 735,000 | 735,000 | 1.000 | 1.000 | 0.0% | 0.0% | 735,000 | 735,000 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 96 | 771,750 | 771,750 | 764,033 | 1.000 | 1.010 | 0.0% | 1.0% | 771,750 | 771,750 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 84 | 810,338 | 810,338 | 802,234 | 1.000 | 1.010 | 0.0% | 1.0% | 810,338 | 810,338 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 72 | 850,854 | 842,346 | 833,837 | 1.010 | 1.020 | 1.0% | 2.0% | 850,854 | 850,854 | 8,509 | 8,509 | 8,509 | 0 | 0 |
| 2004 | 60 | 893,397 | 884,463 | 857,661 | 1.010 | 1.042 | 1.0% | 4.0% | 893,397 | 893,397 | 8,934 | 8,934 | 8,934 | 0 | 0 |
| 2005 | 48 | 938,067 | 919,306 | 863,022 | 1.020 | 1.087 | 2.0% | 8.0% | 938,067 | 938,067 | 18,761 | 18,761 | 18,761 | 0 | 0 |
| 2006 | 36 | 984,970 | 935,722 | 827,375 | 1.053 | 1.190 | 5.0% | 16.0% | 984,970 | 984,970 | 49,249 | 49,249 | 49,249 | 0 | - 0 |
| 2007 | 24 | 1,034,219 | 930,797 | 734,295 | 1.111 | 1.408 | 10.0% | 29.0% | 1,034,219 | 1,034,219 | 103,422 | 103,422 | 103,422 | 0 | 0 |
| 2008 | 12 | 1,085,930 | 836,166 | 456,090 | 1.299 | 2.381 | 23.0% | 58.0% | 1,085,930 | 1,085,930 | 249,764 | 249,764 | 249,764 | 0 | - 0 |
| Total | | 8,804,525 | 8,365,887 | 7,573,548 | | | | | 8,804,525 | 8,804,525 | 438,638 | 438,638 | 438,638 | 0 | 0 |
| **Increasing Claim Ratios** | | | | | | | | | | | | | | | |
| 1999 | 120 | 700,000 | 700,000 | 700,000 | 1.000 | 1.000 | 0.0% | 0.0% | 700,000 | 700,000 | 0 | 0 | 0 | 0 | 0 |
| 2000 | 108 | 735,000 | 735,000 | 735,000 | 1.000 | 1.000 | 0.0% | 0.0% | 735,000 | 735,000 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 96 | 771,750 | 771,750 | 764,033 | 1.000 | 1.010 | 0.0% | 1.0% | 771,750 | 771,750 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 84 | 810,338 | 810,338 | 802,234 | 1.000 | 1.010 | 0.0% | 1.0% | 810,338 | 810,338 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 72 | 850,854 | 842,346 | 833,837 | 1.010 | 1.020 | 1.0% | 2.0% | 850,854 | 850,854 | 8,509 | 8,509 | 8,509 | 0 | 0 |
| 2004 | 60 | 893,397 | 1,010,815 | 980,184 | 1.010 | 1.042 | 1.0% | 4.0% | 1,019,749 | 1,015,920 | 8,934 | 5,105 | 10,210 | 1,276 | 5,105 |
| 2005 | 48 | 938,067 | 1,116,300 | 1,047,955 | 1.020 | 1.087 | 2.0% | 8.0% | 1,135,061 | 1,123,000 | 18,761 | 6,700 | 22,782 | 4,020 | 16,081 |
| 2006 | 36 | 984,970 | 1,203,071 | 1,063,768 | 1.053 | 1.190 | 5.0% | 16.0% | 1,252,319 | 1,221,363 | 49,249 | 18,292 | 63,320 | 14,071 | 45,027 |
| 2007 | 24 | 1,034,219 | 1,263,224 | 996,544 | 1.111 | 1.408 | 10.0% | 29.0% | 1,366,646 | 1,296,467 | 103,422 | 33,243 | 140,358 | 36,936 | 107,116 |
| 2008 | 12 | 1,085,930 | 1,194,523 | 651,558 | 1.299 | 2.381 | 23.0% | 58.0% | 1,444,287 | 1,281,397 | 249,764 | 86,874 | 356,805 | 107,042 | 269,931 |
| Total | | 8,804,525 | 9,647,366 | 8,575,112 | | | | | 10,086,004 | 9,806,090 | 438,638 | 158,724 | 601,984 | 163,346 | 443,260 |

Column Notes:
(2) Age of accident year at December 31, 2008.
(3) See Chapter 8, Exhibit IV, Sheet 1.
(4) and (5) From last diagonal of reported and paid claim triangles in Chapter 7, Exhibit III, Sheets 2 through 5.
(6) and (7) CDF based on 5-year simple average age-to-age factors presented in Chapter 7, Exhibit III, Sheets 2 through 5.
(8) = [1.00 - (1.00 / (6))].
(9) = [1.00 - (1.00 / (7))].
(10) = [((3) x (8)) + (4)].
(11) = [((3) x (9)) + (5)].
(12) = [(10) - (4)].
(13) = [(11) - (4)].
(14) Developed in Chapter 7, Exhibit III, Sheet 1.
(15) = [(14) - (12)].
(16) = [(14) - (13)].

| Accident | Age of Accident Year | Expected | Claims at 12/31/08 | | CDF to Ultimate | | Expected Percentage | | Projected Ultimate Claims Using B-F Method with | | Estimated IBNR Using B-F Method with | | Actual | Diff from Actual IBNR Using B-F Method with | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | at 12/31/08 | Claims | Reported | Paid | Reported | Paid | Unreported | Unpaid | Reported | Paid | Reported | Paid | IBNR | Reported | Paid |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| **Increasing Case Outstanding Strength** | | | | | | | | | | | | | | | |
| 1999 | 120 | 700,000 | 700,000 | 700,000 | 1.000 | 1.000 | 0.0% | 0.0% | 700,000 | 700,000 | 0 | 0 | 0 | 0 | 0 |
| 2000 | 108 | 735,000 | 735,000 | 735,000 | 1.000 | 1.000 | 0.0% | 0.0% | 735,000 | 735,000 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 96 | 771,750 | 771,750 | 764,033 | 1.000 | 1.010 | 0.0% | 1.0% | 771,750 | 771,750 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 84 | 810,338 | 810,338 | 802,234 | 1.000 | 1.010 | 0.0% | 1.0% | 810,338 | 810,338 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 72 | 850,854 | 842,346 | 833,837 | 1.010 | 1.020 | 1.0% | 2.0% | 850,854 | 850,854 | 8,509 | 8,509 | 8,509 | 0 | 0 |
| 2004 | 60 | 893,397 | 884,463 | 857,661 | 1.010 | 1.042 | 1.0% | 4.0% | 893,397 | 893,397 | 8,934 | 8,934 | 8,934 | 0 | 0 |
| 2005 | 48 | 938,067 | 933,377 | 863,022 | 1.020 | 1.087 | 1.9% | 8.0% | 951,395 | 938,067 | 18,018 | 4,690 | 4,690 | - 13,328 | 0 |
| 2006 | 36 | 984,970 | 962,808 | 827,375 | 1.055 | 1.190 | 5.2% | 16.0% | 1,013,733 | 984,970 | 50,925 | 22,162 | 22,162 | - 28,763 | - 0 |
| 2007 | 24 | 1,034,219 | 979,922 | 734,295 | 1.119 | 1.408 | 10.6% | 29.0% | 1,089,655 | 1,034,219 | 109,733 | 54,296 | 54,296 | - 55,437 | 0 |
| 2008 | 12 | 1,085,930 | 931,185 | 456,090 | 1.318 | 2.381 | 24.1% | 58.0% | 1,193,385 | 1,085,930 | 262,200 | 154,745 | 154,745 | - 107,455 | - 0 |
| Total | | 8,804,525 | 8,551,189 | 7,573,548 | | | | | 9,009,508 | 8,804,525 | 458,319 | 253,336 | 253,336 | - 204,983 | 0 |
| **Increasing Claim Ratios and Case Outstanding Strength** | | | | | | | | | | | | | | | |
| 1999 | 120 | 700,000 | 700,000 | 700,000 | 1.000 | 1.000 | 0.0% | 0.0% | 700,000 | 700,000 | 0 | 0 | 0 | 0 | 0 |
| 2000 | 108 | 735,000 | 735,000 | 735,000 | 1.000 | 1.000 | 0.0% | 0.0% | 735,000 | 735,000 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 96 | 771,750 | 771,750 | 764,033 | 1.000 | 1.010 | 0.0% | 1.0% | 771,750 | 771,750 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 84 | 810,338 | 810,338 | 802,234 | 1.000 | 1.010 | 0.0% | 1.0% | 810,338 | 810,338 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 72 | 850,854 | 842,346 | 833,837 | 1.010 | 1.020 | 1.0% | 2.0% | 850,854 | 850,854 | 8,509 | 8,509 | 8,509 | 0 | 0 |
| 2004 | 60 | 893,397 | 1,010,815 | 980,184 | 1.010 | 1.042 | 1.0% | 4.0% | 1,019,749 | 1,015,920 | 8,934 | 5,105 | 10,210 | 1,276 | 5,105 |
| 2005 | 48 | 938,067 | 1,133,386 | 1,047,955 | 1.019 | 1.087 | 1.9% | 8.0% | 1,151,324 | 1,123,000 | 17,938 | - 10,386 | 5,695 | - 12,243 | 16,081 |
| 2006 | 36 | 984,970 | 1,237,897 | 1,063,768 | 1.055 | 1.190 | 5.2% | 16.0% | 1,289,001 | 1,221,363 | 51,105 | - 16,533 | 28,494 | - 22,611 | 45,027 |
| 2007 | 24 | 1,034,219 | 1,329,895 | 996,544 | 1.120 | 1.408 | 10.7% | 29.0% | 1,440,327 | 1,296,467 | 110,432 | - 33,427 | 73,688 | - 36,744 | 107,116 |
| 2008 | 12 | 1,085,930 | 1,330,264 | 651,558 | 1.320 | 2.381 | 24.3% | 58.0% | 1,593,780 | 1,281,397 | 263,516 | - 48,867 | 221,064 | - 42,452 | 269,931 |
| Total | | 8,804,525 | 9,901,689 | 8,575,112 | | | | | 10,362,123 | 9,806,090 | 460,434 | - 95,600 | 347,660 | - 112,773 | 443,260 |

Column Notes:
(2) Age of accident year at December 31, 2008.
(3) See Chapter 8, Exhibit IV, Sheet 2.
(4) and (5) From last diagonal of reported and paid claim triangles in Chapter 7, Exhibit III, Sheets 6 through 9.
(6) and (7) CDF based on 5-year simple average age-to-age factors presented in Chapter 7, Exhibit III, Sheets 6 through 9.
(8) = [1.00 - (1.00 / (6))].
(9) = [1.00 - (1.00 / (7))].
(10) = [((3) x (8)) + (4)].
(11) = [((3) x (9)) + (5)].
(12) = [(10) - (4)].
(13) = [(11) - (4)].
(14) Developed in Chapter 7, Exhibit III, Sheet 1.
(15) = [(14) - (12)].
(16) = [(14) - (13)].

**Chapter 9 - Bornhuetter-Ferguson Technique**
**Impact of Change in Product Mix Example**
**U.S. Auto - Development of Unpaid Claim Estimate**

| Accident | Age of Accident Year | Expected | Claims at 12/31/08 | | CDF to Ultimate | | Expected Percentage | | Projected Ultimate Claims Using B-F Method with | | Estimated IBNR Using B-F Method with | | Actual | Diff from Actual IBNR Using B-F Method with | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | at 12/31/08 | Claims | Reported | Paid | Reported | Paid | Unreported | Unpaid | Reported | Paid | Reported | Paid | IBNR | Reported | Paid |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| **Steady-State (No Change in Product Mix)** | | | | | | | | | | | | | | | |
| 1999 | 120 | 1,500,000 | 1,500,000 | 1,500,000 | 1.000 | 1.000 | 0.0% | 0.0% | 1,500,000 | 1,500,000 | 0 | 0 | 0 | 0 | 0 |
| 2000 | 108 | 1,575,000 | 1,575,000 | 1,566,600 | 1.000 | 1.005 | 0.0% | 0.5% | 1,575,000 | 1,575,000 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 96 | 1,653,750 | 1,653,750 | 1,628,393 | 1.000 | 1.016 | 0.0% | 1.5% | 1,653,750 | 1,653,750 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 84 | 1,736,438 | 1,736,438 | 1,700,551 | 1.000 | 1.021 | 0.0% | 2.1% | 1,736,438 | 1,736,438 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 72 | 1,823,259 | 1,814,751 | 1,757,622 | 1.005 | 1.037 | 0.5% | 3.6% | 1,823,259 | 1,823,259 | 8,509 | 8,509 | 8,509 | 0 | 0 |
| 2004 | 60 | 1,914,422 | 1,885,068 | 1,786,794 | 1.016 | 1.071 | 1.5% | 6.7% | 1,914,422 | 1,914,422 | 29,354 | 29,354 | 29,354 | 0 | 0 |
| 2005 | 48 | 2,010,143 | 1,948,499 | 1,742,124 | 1.032 | 1.154 | 3.1% | 13.3% | 2,010,143 | 2,010,143 | 61,644 | 61,644 | 61,644 | 0 | 0 |
| 2006 | 36 | 2,110,651 | 1,937,577 | 1,581,581 | 1.089 | 1.335 | 8.2% | 25.1% | 2,110,651 | 2,110,651 | 173,073 | 173,073 | 173,073 | 0 | 0 |
| 2007 | 24 | 2,216,183 | 1,852,729 | 1,277,999 | 1.196 | 1.734 | 16.4% | 42.3% | 2,216,183 | 2,216,183 | 363,454 | 363,454 | 363,454 | 0 | 0 |
| 2008 | 12 | 2,326,992 | 1,568,393 | 729,124 | 1.484 | 3.191 | 32.6% | 68.7% | 2,326,992 | 2,326,992 | 758,599 | 758,599 | 758,599 | 0 | 0 |
| Total | | 18,866,839 | 17,472,204 | 15,270,788 | | | | | 18,866,839 | 18,866,839 | 1,394,634 | 1,394,634 | 1,394,634 | 0 | 0 |
| **Changing Product Mix** | | | | | | | | | | | | | | | |
| 1999 | 120 | 1,500,000 | 1,500,000 | 1,500,000 | 1.000 | 1.000 | 0.0% | 0.0% | 1,500,000 | 1,500,000 | 0 | 0 | 0 | 0 | 0 |
| 2000 | 108 | 1,575,000 | 1,575,000 | 1,566,600 | 1.000 | 1.005 | 0.0% | 0.5% | 1,575,000 | 1,575,000 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 96 | 1,653,750 | 1,653,750 | 1,628,393 | 1.000 | 1.016 | 0.0% | 1.5% | 1,653,750 | 1,653,750 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 84 | 1,736,438 | 1,736,438 | 1,700,551 | 1.000 | 1.021 | 0.0% | 2.1% | 1,736,438 | 1,736,438 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 72 | 1,823,259 | 1,814,751 | 1,757,622 | 1.005 | 1.037 | 0.5% | 3.6% | 1,823,259 | 1,823,259 | 8,509 | 8,509 | 8,509 | 0 | 0 |
| 2004 | 60 | 1,914,422 | 1,885,068 | 1,786,794 | 1.016 | 1.071 | 1.5% | 6.7% | 1,914,422 | 1,914,422 | 29,354 | 29,354 | 29,354 | 0 | 0 |
| 2005 | 48 | 2,249,446 | 2,193,545 | 1,951,435 | 1.032 | 1.154 | 3.1% | 13.3% | 2,262,528 | 2,251,361 | 68,983 | 57,816 | 71,855 | 2,872 | 14,039 |
| 2006 | 36 | 2,673,012 | 2,471,446 | 1,983,482 | 1.090 | 1.336 | 8.3% | 25.2% | 2,692,025 | 2,656,353 | 220,579 | 184,907 | 239,057 | 18,478 | 54,150 |
| 2007 | 24 | 3,211,085 | 2,680,487 | 1,766,164 | 1.200 | 1.750 | 16.7% | 42.9% | 3,216,658 | 3,142,865 | 536,171 | 462,378 | 596,924 | 60,753 | 134,547 |
| 2008 | 12 | 3,897,387 | 2,556,695 | 1,097,644 | 1.503 | 3.273 | 33.5% | 69.4% | 3,860,964 | 3,804,378 | 1,304,270 | 1,247,684 | 1,445,385 | 141,115 | 197,702 |
| Total | | 22,233,799 | 20,067,179 | 16,738,684 | | | | | 22,235,045 | 22,057,826 | 2,167,866 | 1,990,647 | 2,391,084 | 223,219 | 400,438 |

Column Notes:
(2) Age of accident year at December 31, 2008.
(3) See Chapter 8, Exhibit V.
(4) and (5) From last diagonal of reported and paid claim triangles in Chapter 7, Exhibit IV, Sheets 2 through 5.
(6) and (7) CDF based on 5-year simple average age-to-age factors presented in Chapter 7, Exhibit IV, Sheets 2 through 5.
(8) = [1.00 - (1.00 / (6))].
(9) = [1.00 - (1.00 / (7))].
(10) = [((3) x (8)) + (4)].
(11) = [((3) x (9)) + (5)].
(12) = [(10) - (4)].
(13) = [(11) - (4)].
(14) Developed in Chapter 7, Exhibit IV, Sheet 1.
(15) = [(14) - (12)].
(16) = [(14) - (13)].

| Accident Year | Age of Accident Year at 12/31/08 | Expected Ultimate Claims Using B-F Method with Reported | Paid | Claims at 12/31/08 Reported | Paid | CDF to Ultimate Reported | Paid | Expected Percentage Unreported | Unpaid | Projected Ultimate Claims Using G-B Method with Reported | Paid | Estimated IBNR Using G-B Method with Reported | Paid | Actual IBNR | Diff from Actual IBNR Using G-B Method with Reported | Paid |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
| **Steady-State** | | | | | | | | | | | | | | | | |
| 1999 | 120 | 700,000 | 700,000 | 700,000 | 700,000 | 1.000 | 1.000 | 0.0% | 0.0% | 700,000 | 700,000 | 0 | 0 | 0 | 0 | 0 |
| 2000 | 108 | 735,000 | 735,000 | 735,000 | 735,000 | 1.000 | 1.000 | 0.0% | 0.0% | 735,000 | 735,000 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 96 | 771,750 | 771,750 | 771,750 | 764,033 | 1.000 | 1.010 | 0.0% | 1.0% | 771,750 | 771,750 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 84 | 810,338 | 810,338 | 810,338 | 802,234 | 1.000 | 1.010 | 0.0% | 1.0% | 810,338 | 810,338 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 72 | 850,854 | 850,854 | 842,346 | 833,837 | 1.010 | 1.020 | 1.0% | 2.0% | 850,854 | 850,854 | 8,509 | 8,509 | 8,509 | 0 | 0 |
| 2004 | 60 | 893,397 | 893,397 | 884,463 | 857,661 | 1.010 | 1.042 | 1.0% | 4.0% | 893,397 | 893,397 | 8,934 | 8,934 | 8,934 | 0 | 0 |
| 2005 | 48 | 938,067 | 938,067 | 919,306 | 863,022 | 1.020 | 1.087 | 2.0% | 8.0% | 938,067 | 938,067 | 18,761 | 18,761 | 18,761 | 0 | 0 |
| 2006 | 36 | 984,970 | 984,970 | 935,722 | 827,375 | 1.053 | 1.190 | 5.0% | 16.0% | 984,970 | 984,970 | 49,249 | 49,249 | 49,249 | 0 | - 0 |
| 2007 | 24 | 1,034,219 | 1,034,219 | 930,797 | 734,295 | 1.111 | 1.408 | 10.0% | 29.0% | 1,034,219 | 1,034,219 | 103,422 | 103,422 | 103,422 | 0 | 0 |
| 2008 | 12 | 1,085,930 | 1,085,930 | 836,166 | 456,090 | 1.299 | 2.381 | 23.0% | 58.0% | 1,085,930 | 1,085,930 | 249,764 | 249,764 | 249,764 | 0 | - 0 |
| Total | | 8,804,525 | 8,804,525 | 8,365,887 | 7,573,548 | | | | | 8,804,525 | 8,804,525 | 438,638 | 438,638 | 438,638 | 0 | - 0 |
| **Increasing Claim Ratios** | | | | | | | | | | | | | | | | |
| 1999 | 120 | 700,000 | 700,000 | 700,000 | 700,000 | 1.000 | 1.000 | 0.0% | 0.0% | 700,000 | 700,000 | 0 | 0 | 0 | 0 | 0 |
| 2000 | 108 | 735,000 | 735,000 | 735,000 | 735,000 | 1.000 | 1.000 | 0.0% | 0.0% | 735,000 | 735,000 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 96 | 771,750 | 771,750 | 771,750 | 764,033 | 1.000 | 1.010 | 0.0% | 1.0% | 771,750 | 771,750 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 84 | 810,338 | 810,338 | 810,338 | 802,234 | 1.000 | 1.010 | 0.0% | 1.0% | 810,338 | 810,338 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 72 | 850,854 | 850,854 | 842,346 | 833,837 | 1.010 | 1.020 | 1.0% | 2.0% | 850,854 | 850,854 | 8,509 | 8,509 | 8,509 | 0 | 0 |
| 2004 | 60 | 1,019,749 | 1,015,920 | 1,010,815 | 980,184 | 1.010 | 1.042 | 1.0% | 4.0% | 1,021,012 | 1,020,821 | 10,197 | 10,006 | 10,210 | 13 | 204 |
| 2005 | 48 | 1,135,061 | 1,123,000 | 1,116,300 | 1,047,955 | 1.020 | 1.087 | 2.0% | 8.0% | 1,139,001 | 1,137,795 | 22,701 | 21,495 | 22,782 | 80 | 1,286 |
| 2006 | 36 | 1,252,319 | 1,221,363 | 1,203,071 | 1,063,768 | 1.053 | 1.190 | 5.0% | 16.0% | 1,265,687 | 1,259,186 | 62,616 | 56,115 | 63,320 | 704 | 7,204 |
| 2007 | 24 | 1,366,646 | 1,296,467 | 1,263,224 | 996,544 | 1.111 | 1.408 | 10.0% | 29.0% | 1,399,889 | 1,372,519 | 136,665 | 109,295 | 140,358 | 3,694 | 31,064 |
| 2008 | 12 | 1,444,287 | 1,281,397 | 1,194,523 | 651,558 | 1.299 | 2.381 | 23.0% | 58.0% | 1,526,709 | 1,394,768 | 332,186 | 200,245 | 356,805 | 24,620 | 156,560 |
| Total | | 10,086,004 | 9,806,090 | 9,647,366 | 8,575,112 | | | | | 10,220,240 | 10,053,031 | 572,874 | 405,665 | 601,984 | 29,110 | 196,319 |

Column Notes:
(2) Age of accident year at December 31, 2008.
(3) and (4) Developed in Exhibit III, Sheet 1.
(5) and (6) From last diagonal of reported and paid claim triangles in Chapter 7, Exhibit III, Sheets 2 through 5.
(7) and (8) CDF based on 5-year simple average age-to-age factors presented in Chapter 7, Exhibit III, Sheets 2 through 5.
(9) = [1.00 - (1.00 / (7))].
(10) = [1.00 - (1.00 / (8))].
(11) = [((3) x (9)) + (5)].
(12) = [((4) x (10)) + (6)].
(13) = [(11) - (5)].
(14) = [(12) - (5)].
(15) Developed in Chapter 7, Exhibit III, Sheet 1.
(16) = [(15) - (13)].
(17) = [(15) - (14)].

| Accident | Age of Accident Year | Expected Ultimate Claims Using B-F Method with | | Claims at 12/31/08 | | CDF to Ultimate | | Expected Percentage | | Projected Ultimate Claims Using G-B Method with | | Estimated IBNR Using G-B Method with | | Actual | Diff from Actual IBNR Using G-B Method with | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | at 12/31/08 | Reported | Paid | Reported | Paid | Reported | Paid | Unreported | Unpaid | Reported | Paid | Reported | Paid | IBNR | Reported | Paid |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
| **Increasing Case Outstanding Strength** | | | | | | | | | | | | | | | | |
| 1999 | 120 | 700,000 | 700,000 | 700,000 | 700,000 | 1.000 | 1.000 | 0.0% | 0.0% | 700,000 | 700,000 | 0 | 0 | 0 | 0 | 0 |
| 2000 | 108 | 735,000 | 735,000 | 735,000 | 735,000 | 1.000 | 1.000 | 0.0% | 0.0% | 735,000 | 735,000 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 96 | 771,750 | 771,750 | 771,750 | 764,033 | 1.000 | 1.010 | 0.0% | 1.0% | 771,750 | 771,750 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 84 | 810,338 | 810,338 | 810,338 | 802,234 | 1.000 | 1.010 | 0.0% | 1.0% | 810,338 | 810,338 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 72 | 850,854 | 850,854 | 842,346 | 833,837 | 1.010 | 1.020 | 1.0% | 2.0% | 850,854 | 850,854 | 8,509 | 8,509 | 8,509 | 0 | 0 |
| 2004 | 60 | 893,397 | 893,397 | 884,463 | 857,661 | 1.010 | 1.042 | 1.0% | 4.0% | 893,397 | 893,397 | 8,934 | 8,934 | 8,934 | 0 | 0 |
| 2005 | 48 | 951,395 | 938,067 | 933,377 | 863,022 | 1.020 | 1.087 | 1.9% | 8.0% | 951,651 | 938,067 | 18,274 | 4,690 | 4,690 | - 13,584 | 0 |
| 2006 | 36 | 1,013,733 | 984,970 | 962,808 | 827,375 | 1.055 | 1.190 | 5.2% | 16.0% | 1,015,221 | 984,970 | 52,412 | 22,162 | 22,162 | - 30,250 | - 0 |
| 2007 | 24 | 1,089,655 | 1,034,219 | 979,922 | 734,295 | 1.119 | 1.408 | 10.6% | 29.0% | 1,095,537 | 1,034,219 | 115,615 | 54,296 | 54,296 | - 61,319 | 0 |
| 2008 | 12 | 1,193,385 | 1,085,930 | 931,185 | 456,090 | 1.318 | 2.381 | 24.1% | 58.0% | 1,219,330 | 1,085,930 | 288,146 | 154,745 | 154,745 | - 133,401 | - 0 |
| Total | | 9,009,508 | 8,804,525 | 8,551,189 | 7,573,548 | | | | | 9,043,078 | 8,804,525 | 491,890 | 253,336 | 253,336 | - 238,553 | - 0 |
| **Increasing Claim Ratios and Case Outstanding Strength** | | | | | | | | | | | | | | | | |
| 1999 | 120 | 700,000 | 700,000 | 700,000 | 700,000 | 1.000 | 1.000 | 0.0% | 0.0% | 700,000 | 700,000 | 0 | 0 | 0 | 0 | 0 |
| 2000 | 108 | 735,000 | 735,000 | 735,000 | 735,000 | 1.000 | 1.000 | 0.0% | 0.0% | 735,000 | 735,000 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 96 | 771,750 | 771,750 | 771,750 | 764,033 | 1.000 | 1.010 | 0.0% | 1.0% | 771,750 | 771,750 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 84 | 810,338 | 810,338 | 810,338 | 802,234 | 1.000 | 1.010 | 0.0% | 1.0% | 810,338 | 810,338 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 72 | 850,854 | 850,854 | 842,346 | 833,837 | 1.010 | 1.020 | 1.0% | 2.0% | 850,854 | 850,854 | 8,509 | 8,509 | 8,509 | 0 | 0 |
| 2004 | 60 | 1,019,749 | 1,015,920 | 1,010,815 | 980,184 | 1.010 | 1.042 | 1.0% | 4.0% | 1,021,012 | 1,020,821 | 10,197 | 10,006 | 10,210 | 13 | 204 |
| 2005 | 48 | 1,151,324 | 1,123,000 | 1,133,386 | 1,047,955 | 1.019 | 1.087 | 1.9% | 8.0% | 1,155,402 | 1,137,795 | 22,016 | 4,409 | 5,695 | - 16,321 | 1,286 |
| 2006 | 36 | 1,289,001 | 1,221,363 | 1,237,897 | 1,063,768 | 1.055 | 1.190 | 5.2% | 16.0% | 1,304,776 | 1,259,186 | 66,879 | 21,289 | 28,494 | - 38,385 | 7,204 |
| 2007 | 24 | 1,440,327 | 1,296,467 | 1,329,895 | 996,544 | 1.120 | 1.408 | 10.7% | 29.0% | 1,483,691 | 1,372,519 | 153,796 | 42,625 | 73,688 | - 80,108 | 31,064 |
| 2008 | 12 | 1,593,780 | 1,281,397 | 1,330,264 | 651,558 | 1.320 | 2.381 | 24.3% | 58.0% | 1,717,017 | 1,394,768 | 386,753 | 64,504 | 221,064 | - 165,689 | 156,560 |
| Total | | 10,362,123 | 9,806,090 | 9,901,689 | 8,575,112 | | | | | 10,549,840 | 10,053,031 | 648,150 | 151,342 | 347,660 | - 300,490 | 196,319 |

Column Notes:
(2) Age of accident year at December 31, 2008.
(3) and (4) Developed in Exhibit III, Sheet 2.
(5) and (6) From last diagonal of reported and paid claim triangles in Chapter 7, Exhibit III, Sheets 6 through 9.
(7) and (8) CDF based on 5-year simple average age-to-age factors presented in Chapter 7, Exhibit III, Sheets 6 through 9.
(9) = [1.00 - (1.00 / (7))].
(10) = [1.00 - (1.00 / (8))].
(11) = [((3) x (9)) + (5)].
(12) = [((4) x (10)) + (6)].
(13) = [(11) - (5)].
(14) = [(12) - (5)].
(15) Developed in Chapter 7, Exhibit III, Sheet 1.
(16) = [(15) - (13)].
(17) = [(15) - (14)].

| Accident Year | Age of Accident Year at 12/31/08 | Expected Ultimate Claims Using B-F Method with | | Claims at 12/31/08 | | CDF to Ultimate | | Expected Percentage | | Projected Ultimate Claims Using G-B Method with | | Estimated IBNR Using G-B Method with | | Actual IBNR | Diff from Actual IBNR Using G-B Method with | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Reported | Paid | Reported | Paid | Reported | Paid | Unreported | Unpaid | Reported | Paid | Reported | Paid | | Reported | Paid |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
| **Steady-State (No Change in Product Mix)** | | | | | | | | | | | | | | | | |
| 1999 | 120 | 1,500,000 | 1,500,000 | 1,500,000 | 1,500,000 | 1.000 | 1.000 | 0.0% | 0.0% | 1,500,000 | 1,500,000 | 0 | 0 | 0 | 0 | 0 |
| 2000 | 108 | 1,575,000 | 1,575,000 | 1,575,000 | 1,566,600 | 1.000 | 1.005 | 0.0% | 0.5% | 1,575,000 | 1,575,000 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 96 | 1,653,750 | 1,653,750 | 1,653,750 | 1,628,393 | 1.000 | 1.016 | 0.0% | 1.5% | 1,653,750 | 1,653,750 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 84 | 1,736,438 | 1,736,438 | 1,736,438 | 1,700,551 | 1.000 | 1.021 | 0.0% | 2.1% | 1,736,438 | 1,736,438 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 72 | 1,823,259 | 1,823,259 | 1,814,751 | 1,757,622 | 1.005 | 1.037 | 0.5% | 3.6% | 1,823,259 | 1,823,259 | 8,509 | 8,509 | 8,509 | 0 | 0 |
| 2004 | 60 | 1,914,422 | 1,914,422 | 1,885,068 | 1,786,794 | 1.016 | 1.071 | 1.5% | 6.7% | 1,914,422 | 1,914,422 | 29,354 | 29,354 | 29,354 | 0 | 0 |
| 2005 | 48 | 2,010,143 | 2,010,143 | 1,948,499 | 1,742,124 | 1.032 | 1.154 | 3.1% | 13.3% | 2,010,143 | 2,010,143 | 61,644 | 61,644 | 61,644 | 0 | 0 |
| 2006 | 36 | 2,110,651 | 2,110,651 | 1,937,577 | 1,581,581 | 1.089 | 1.335 | 8.2% | 25.1% | 2,110,651 | 2,110,651 | 173,073 | 173,073 | 173,073 | 0 | 0 |
| 2007 | 24 | 2,216,183 | 2,216,183 | 1,852,729 | 1,277,999 | 1.196 | 1.734 | 16.4% | 42.3% | 2,216,183 | 2,216,183 | 363,454 | 363,454 | 363,454 | 0 | 0 |
| 2008 | 12 | 2,326,992 | 2,326,992 | 1,568,393 | 729,124 | 1.484 | 3.191 | 32.6% | 68.7% | 2,326,992 | 2,326,992 | 758,599 | 758,599 | 758,599 | - 0 | 0 |
| Total | | 18,866,839 | 18,866,839 | 17,472,204 | 15,270,788 | | | | | 18,866,839 | 18,866,839 | 1,394,634 | 1,394,634 | 1,394,634 | 0 | 0 |
| **Changing Product Mix** | | | | | | | | | | | | | | | | |
| 1999 | 120 | 1,500,000 | 1,500,000 | 1,500,000 | 1,500,000 | 1.000 | 1.000 | 0.0% | 0.0% | 1,500,000 | 1,500,000 | 0 | 0 | 0 | 0 | 0 |
| 2000 | 108 | 1,575,000 | 1,575,000 | 1,575,000 | 1,566,600 | 1.000 | 1.005 | 0.0% | 0.5% | 1,575,000 | 1,575,000 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 96 | 1,653,750 | 1,653,750 | 1,653,750 | 1,628,393 | 1.000 | 1.016 | 0.0% | 1.5% | 1,653,750 | 1,653,750 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 84 | 1,736,438 | 1,736,438 | 1,736,438 | 1,700,551 | 1.000 | 1.021 | 0.0% | 2.1% | 1,736,438 | 1,736,438 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 72 | 1,823,259 | 1,823,259 | 1,814,751 | 1,757,622 | 1.005 | 1.037 | 0.5% | 3.6% | 1,823,259 | 1,823,259 | 8,509 | 8,509 | 8,509 | 0 | 0 |
| 2004 | 60 | 1,914,422 | 1,914,422 | 1,885,068 | 1,786,794 | 1.016 | 1.071 | 1.5% | 6.7% | 1,914,422 | 1,914,422 | 29,354 | 29,354 | 29,354 | 0 | 0 |
| 2005 | 48 | 2,262,528 | 2,251,361 | 2,193,545 | 1,951,435 | 1.032 | 1.154 | 3.1% | 13.3% | 2,262,929 | 2,251,616 | 69,384 | 58,071 | 71,855 | 2,470 | 13,784 |
| 2006 | 36 | 2,692,025 | 2,656,353 | 2,471,446 | 1,983,482 | 1.090 | 1.336 | 8.3% | 25.2% | 2,693,594 | 2,652,159 | 222,148 | 180,713 | 239,057 | 16,909 | 58,344 |
| 2007 | 24 | 3,216,658 | 3,142,865 | 2,680,487 | 1,766,164 | 1.200 | 1.750 | 16.7% | 42.9% | 3,217,588 | 3,113,616 | 537,101 | 433,129 | 596,924 | 59,823 | 163,795 |
| 2008 | 12 | 3,860,964 | 3,804,378 | 2,556,695 | 1,097,644 | 1.503 | 3.273 | 33.5% | 69.4% | 3,848,776 | 3,739,784 | 1,292,081 | 1,183,089 | 1,445,385 | 153,304 | 262,296 |
| Total | | 22,235,045 | 22,057,826 | 20,067,179 | 16,738,684 | | | | | 22,225,757 | 21,960,044 | 2,158,578 | 1,892,866 | 2,391,084 | 232,507 | 498,219 |

Column Notes:
(2) Age of accident year at December 31, 2008.
(3) and (4) Developed in Exhibit IV.
(5) and (6) From last diagonal of reported and paid claim triangles in Chapter 7, Exhibit IV, Sheets 2 through 5.
(7) and (8) CDF based on 5-year simple average age-to-age factors presented in Chapter 7, Exhibit IV, Sheets 2 through 5.
(9) = [1.00 - (1.00 / (7))].
(10) = [1.00 - (1.00 / (8))].
(11) = [((3) x (9)) + (5)].
(12) = [((4) x (10)) + (6)].
(13) = [(11) - (5)].
(14) = [(12) - (5)].
(15) Developed in Chapter 7, Exhibit IV, Sheet 1.
(16) = [(15) - (13)].
(17) = [(15) - (14)].

# CHAPTER 10 – CAPE COD TECHNIQUE

The Cape Cod method, also known as the Stanard-Buhlmann method, is similar to the Bornhuetter-Ferguson technique. As in the Bornhuetter-Ferguson technique, the Cape Cod method splits ultimate claims into two components: actual reported (or paid) and expected unreported (or unpaid). As an accident year (or other time interval) matures, the actual reported claims replace the expected unreported claims and the initial expected claims assumption becomes gradually less important. The primary difference between the two methods is the derivation of the expected claim ratio. In the Cape Cod technique, the expected claim ratio is obtained from the reported claims experience instead of an independent and often judgmental selection as in the Bornhuetter-Ferguson technique.

## Key Assumptions

The key assumption of the Cape Cod method is that unreported claims will develop based on expected claims, which are derived using reported (or paid) claims and earned premium. Both the Cape Cod and Bornhuetter-Ferguson methods differ from the development method where the primary assumption is that unreported claims will develop based on reported claims to date (not expected claims).

## Common Uses of the Cape Cod Technique

Reinsurers are among the most frequent users of the Cape Cod technique. Actuaries generally use the Cape Cod method in a reported claims application, but they can also use it with paid claims. The technique is appropriate for all lines of insurance including short-tail lines and long-tail lines. Similar to the development and Bornhuetter-Ferguson methods, actuaries using the Cape Cod method can organize data in a variety of different time intervals:

- Accident year
- Policy year
- Underwriting year
- Report year
- Fiscal year

Actuaries can also apply this technique with monthly, quarterly, or semiannual data.

## Mechanics of the Cape Cod Technique

Similar to the Bornhuetter-Ferguson technique, the Cape Cod method is a blend of two other methods: the claim development method and the expected claims method. We restate below the formula of the reported Bornhuetter-Ferguson method, which is the same as the Cape Cod method:

Ultimate Claims = Actual Reported Claims + Expected Unreported Claims

Again, the major difference between the Cape Cod technique and the Bornhuetter-Ferguson is the source of the expected claims. In "Reinsurance" Patrik states:

> The key innovation of the *SB* (Stanard-Buhlmann) Method is that the ultimate expected loss ratio for all years combined is estimated from the overall reported claims experience, instead of being selected judgmentally, as in the *BF* (Bornhuetter-Ferguson) Method. A problem with the *SB* Method is that the *IBNR* by year is highly dependent upon the rate level adjusted premium by year. The user must adjust each year's premium to reflect the rate level cycle on a relative basis. But this is also a problem with the *BF* Method.[58]

In our step-by step example of the Cape Cod method, we use the cumulative claim development patterns presented in Chapter 7. We begin in Exhibit I, Sheet 1, with the development of the estimated claim ratio. In our U.S. Industry Auto example, we do not have details of historical rate level changes. Thus, in both the Bornhuetter-Ferguson method and the Cape Cod method, we rely on unadjusted earned premium data.

In Column (2) of Exhibit I, Sheet 1, we summarize the unadjusted earned premiums by year. Column (3) contains the age of each accident year as of the latest valuation date, December 31, 2007. The reported claims in Column (4) are the latest diagonal in the reported claim development triangle presented in Chapter 7. We also derive the claim development factor to ultimate, Column (5), in Chapter 7. In Column (6), we show the reporting pattern. The percentage reported is equal to the inverse of the cumulative reported claim development factor.

A new concept of the Cape Cod method is the "used-up premium." The used-up premium is the denominator in our determination of the expected claim ratio. This allocation of premium represents the premium corresponding to the claims that are expected to be reported through the valuation date. The used-up premium in Column (7) is equal to the earned premium in Column (2) multiplied by the percentage of claims reported in Column (6). Reinsurers often use ultimate premiums in Column (2) instead of earned premium. In Column (8), we calculate estimated claim ratios, by accident year, by dividing actual reported claims from Column (4) by the used-up premium in Column (7). (An alternative to the use of premium and claim ratios is exposures and pure premiums. Instead of calculating used-up premium, the actuary could calculate used-up exposures and calculate estimated pure premiums instead of estimated claim ratios for each year in the experience period.)

In our U.S. Industry Auto example, we observe a change in the claim ratios for the latest accident years when compared with the earliest years (i.e., 1998 through 2002). The average estimated claim ratio for accident years 1998 through 2002 is 75.2%. For this period of time, the claim ratios vary from a low of 69.6% to a high of 79.7%. We contrast this with the more recent years' experience, which has an average claim ratio of 64.8%. For each year, 2003 through 2007, the estimated claim ratio is less than 67.5%. In the expected claims technique and the Bornhuetter-Ferguson technique, we rely on different claim ratios for the earlier years and the latest years in the experience period to best reflect our expectation of expected claims for each year. In contrast, the Cape Cod method requires the use of the weighted average claim ratio from all years. Thus, one can distinguish the mechanical approach of developing expected claims in the Cape Cod method from the Bornhuetter-Ferguson method in which actuarial judgment plays an important role in the development of the a priori expected claim estimate.

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[58] *Foundations of Casualty Actuarial Science*, 2001. We refer the reader to "Reinsurance" (Chapter 7) for Patrik's complete development of the formulae underlying the Cape Cod technique.

## Unpaid Claim Estimate Based on Cape Cod Technique

We follow a similar procedure for determining the unpaid claim estimate based on the Cape Cod technique as presented in the prior chapters. Estimated IBNR is equal to projected ultimate claims less reported claims and the total unpaid claim estimate is equal to the difference between projected ultimate claims and paid claims.

Exhibit I, Sheet 3 displays the calculations for the estimated unpaid claims of U.S. Industry Auto. Columns (2) and (3) contain reported and paid claims data as of December 31, 2007. We summarize the projected ultimate claims from Exhibit I, Sheet 2 in Column (4). Case outstanding, which are equal to the difference between reported claims and paid claims as of December 31, 2007, are presented in Column (5). Estimated IBNR is equal to projected ultimate claims minus reported claims. We calculate the estimated IBNR based on the Cape Cod technique in Column (6). The total unpaid claim estimate (Column (7)) is equal to the sum of case outstanding and estimated IBNR.

## When the Cape Cod Technique Works and When it Does Not

Similar comments apply to the Cape Cod method as to the Bornhuetter-Ferguson technique. The only difference between the two methods is the derivation of the expected claims. Thus, an advantage of the Cape Cod method, when compared to the development technique, is that it may not be distorted by random fluctuations early in the development of an accident year (or other time interval). A determining factor influencing the fluctuations, in either the Bornhuetter-Ferguson or Cape Cod methods, is the extent to which actual claims for the most recent years affect the derivation of expected claims for such years.

The Cape Cod method is not necessarily as appropriate as the Bornhuetter-Ferguson technique if the data is extremely thin or volatile or both. Since the expected claims are based on reported claims to date, there must be a sufficient volume of credible reported claims in order to derive a reliable expected claims estimate.

It is worthwhile to note that in an ideal situation, the actuary would have the history of rate level changes and would be able to adjust historical premiums to an on-level basis for both the Cape Cod and Bornhuetter-Ferguson projections. The actuary would also adjust claims for trend, benefit-level changes, and other similar factors. From a theoretical perspective, these methods require such adjustment. From a practical perspective, however, such information is often unavailable. In these situations, many actuaries continue to use both the Bornhuetter-Ferguson and Cape Cod methods for the purpose of developing the unpaid claim estimate without the adjustment of premiums or claims. Under such circumstances, it would be prudent for the actuary, when evaluating the results of various techniques and selecting final ultimate claims values, to take into consideration where simplifying assumptions (such as not adjusting premium for rate level changes) were required.

## XYZ Insurer

In Exhibit II, Sheets 1 through 3, we use the Cape Cod technique for XYZ Insurer. There are weaknesses in this projection technique due to the uncertainty in the selected development patterns for reported claims. Due to the numerous changes the insurer has faced, we are uncertain as to the applicability of historical claim development patterns. Since the Cape Cod method uses claim development patterns to calculate the used-up premium, which is a critical component in the expected claim ratio determination, this method may not be appropriate for this example. (Similar to the Bornhuetter-Ferguson method, we limit the reported cumulative claim development factors to a minimum of 1.00 for the Cape Cod technique.)

We have detailed rate change information for XYZ Insurer as well as information regarding the effect of legal reform on the insurance product. We incorporate this information into the Cape Cod projection method presented in Exhibit II. The first adjustment is to restate earned premium for each accident year as if it were at the 2008 rate level. These calculations are contained within Columns (2) through (4) of Exhibit II, Sheet 1. In Columns (6) through (9), we adjust the current reported claims for the influences of inflation (through claims trend factors) and tort reform. Once we have on-level earned premium and adjusted claims, we proceed to calculate estimated claim ratios as described in the previous example for U.S. Industry Auto. We divide the adjusted claims by used-up, on-level premium to derive the claim ratios shown in Column (13). We use the label "Estimated Adjusted Claim Ratios" to indicate that the reported claims are adjusted for inflation and tort reform. We rely on the claim ratio for all years combined, 70.8%, from Column (13) (also shown in Column (14) for each year) as our starting point for developing estimated unadjusted claim ratios in Column (15). These claim ratios, which are adjusted back to the rate level, inflationary level, and tort environment for each accident year, become our starting point for projecting expected claims in Exhibit II, Sheet 2.

We follow the same format as the example for U.S. Industry Auto in Exhibit II, Sheets 2 and 3. We compare the results of the Cape Cod method with the Bornhuetter-Ferguson method, the expected claims method, and the claim development method in Exhibit II, Sheet 4 (projected ultimate claims) and in Exhibit II, Sheet 5 (estimated IBNR).

## Influence of a Changing Environment on the Cape Cod Method[59]

In prior chapters, we discuss the performance of each of the estimation techniques during times of change. We continue these examples using the Cape Cod method.

### Scenario 1 – U.S. PP Auto Steady-State

We see in Chapters 7 through 9 that the development technique, expected claims technique, and Bornhuetter-Ferguson techniques all generate an accurate IBNR value in a steady-state environment. It is not surprising to find that the Cape Cod method also generates the actual IBNR in a steady-state environment. The top section of Exhibit III, Sheets 1 and 3, contains detailed calculations for the Cape Cod method.

[59] We present the following examples to demonstrate the effect of not changing assumption on the resulting projections of ultimate claims and the estimate of unpaid claims. We recognize that the examples are not necessarily representative of real-life applications of the Cape Cod method since we assume that there are no adjustments in expected claims in anticipation of the events that caused higher claim ratios or changes in business mix. Most insurers have a feel for whether a market is getting softer or harder, so they would have a sense as to the direction to adjust the expected claims, if not the absolute amount of adjustment.

## Scenario 2 – U.S. PP Auto Increasing Claim Ratios

Recall that the weakness of the expected claims method, which is the lack of responsiveness to actual emerging claims, is also a weakness of the Bornhuetter-Ferguson method. The Cape Cod method, which derives the expected claim ratio based on reported claims through the valuation date, does not have this same weakness. In Exhibit III, Sheet 1, we see that the estimated claim ratios in Column (8) respond to the changing environment in claims experience. The total all years combined estimated claim ratio is 80.7% for this scenario; this compares to the 70% expected claim ratio for the steady-state.

In the Bornhuetter-Ferguson reported claim projection, there is no change in the estimated IBNR of $438,638 between Scenario 1 and Scenario 2 since the expected claim ratio does not change. However, using the Cape Cod method, the estimated IBNR is $505,828 for Scenario 2. While this value is still short of the actual IBNR requirements of $601,984, the Cape Cod technique is more responsive than the Bornhuetter-Ferguson method when the claim ratios are increasing.

## Scenario 3 – U.S. PP Auto Increasing Case Outstanding Strength

We present the calculations for Scenario 3 in the top section of Exhibit III, Sheets 2 and 4. In this example, we see that the Cape Cod method results in an estimated IBNR that overstates the actual IBNR by an even greater amount than the reported Bornhuetter-Ferguson technique. In the previous chapters, we discuss how the increase in case outstanding strength leads to an increase in the cumulative claim development factors. Whereas the expected claims for Scenario 3 of the Bornhuetter-Ferguson method remain unchanged, the expected claims increase using the Cape Cod method because the method reflects the higher level of reported claims. The projected ultimate claims are increasing for the Cape Cod method under Scenario 3 due to both increasing expected claims and higher claim development factors to ultimate.

## Scenario 4 – U.S. PP Auto Increasing Claim Ratios and Case Outstanding Strength

In times of increasing claim ratios and increasing case outstanding strength, the Cape Cod method can overstate the actual IBNR. In this example, the method responds effectively to the change in claim ratios, however it overreacts to the change in case outstanding adequacy. In our example, the Cape Cod method significantly overstates the actual IBNR needed, indicating that the effect of increasing case outstanding strength exceeds the influence of increasing claim ratios. The estimated claim ratios are driven higher than their true values by the combined effects of both increasing claims and greater adequacy in case outstanding. We present the detailed calculations for Scenario 4 in the bottom section of Exhibit III, Sheets 2 and 4.

## U.S. Auto Steady-State (No Change in Product Mix)

In the last two examples, we present projections for a combined portfolio of private passenger and commercial automobile. In the top section of Exhibit IV, Sheets 1 and 2, we summarize the calculations for the steady-state environment where there is no change in product mix. Similar to our projections using the development and expected claims techniques, we demonstrate in Exhibit IV, Sheet 2 that the Cape Cod technique generates the correct IBNR requirement when there is no change in the product mix.

## U.S. Auto Changing Product Mix

In the final example, we assume that the volume of commercial automobile insurance is increasing at a greater rate than private passenger automobile insurance. In the bottom section of Exhibit IV, Sheet 2, we observe that the Cape Cod method produces estimated IBNR that is lower than the actual IBNR. Even though reported claims are increasing in this scenario when compared to the prior scenario, there are also changes in the reporting pattern. Thus, the Cape Cod method is not responding appropriately to the changing product mix. Detailed calculations are contained within the bottom section of Exhibit IV, Sheets 1 and 2.