Chapter III

DEVELOPMENT OF LOSS RESERVING MODELS:
APPLICATIONS TO AUTOMOBILE INSURANCE
3.1 Introduction:

In automobile insurance, claims due to physical damage or theft are often reported and settled reasonably quickly. But in some other areas, there may be considerable delay between the time of claim inducing event and the determination of the actual amount the company will have to pay in settlement. When an incident leading to a claim occurs, it may not report for some times. In the case of an accident, the incident may quickly report, but it may take a considerable amount of time before it determines actually who is liable and to what extent. Claims originating in a particular year often can not be finalized in that year. For safety, an insurance company needs to know on a regular basis how much it should be setting aside in reserves in order to handle claims arising from incidents that have already occurred, but for which it has not yet known the full extent of its liability (Boland 2006).

In the past, non-life insurance portfolios were financed through a pay-as-you-go system. All claims in a particular year were paid from the premium income of that same year, no matter in which year the claim originated. The financed balance in the portfolio was realized by ensuring that there was equivalence
between the premiums collected and the claims paid in a particular financial year. Technical gains and losses arose because of the difference between the premium income in a year and the claims paid during the year.

Different factors can delay the payment process of claims. For example, long legal procedures are the rule with liability insurance claims. But there may also be other causes for delay, such as the fact that the exact size of the claim is hard to assess. Also, the claim may be filed only later, or more payments than one have to be made, such as in disability insurance. All these factors will lead to delay of the actual payment of the claims. The claims that have already occurred, but are not sufficiently known, are foreseeable in the sense that one knows that payments will have to be made, but not how much the total payment is going to be. Consider also the case that a premium is paid for the claims in a particular year, and a claim arises of which the insurer is not notified as yet. Here also, insurers have losses that have to be reimbursed in future years.

Such claims are now connected to the years for which the premiums were actually paid. This means that reserves have to be kept regarding claims that are known to exist, but for which the eventual size is unknown at the time the reserves have to be set. For claims like these, several acronyms are in use. One has IBNR claims (Incurred but Not Reported) for claims that have occurred but have not been filed. Hence the name IBNR methods, IBNR claims and IBNR reserves for all quantities of this type. There are also RBNS claims (Reported but Not Settled), for claims that are known but not (completely) paid. Other acronyms are IBNFR,
IBNER and RBNFS, where the F is for Fully, the E for Enough. Large claims known to the insurer are often handled on a case-by-case basis. When modeling these situations, one generally starts from a so-called run-off triangle, containing loss figures, for example cumulated payments, for each combination of policy year and development year (Kaas et al, 2001).

Let $C_{ij}$ ($i,j = 1,2,\ldots,n$) be a random variable denote the total claims figure for year of origin $i$ and development year or year of payment $j$, meaning that the claims were paid in calendar year $(i + j - 1)$. Traditionally, these data are presented in a run-off triangle (Table 3.1). The upper part of such triangle $[(i,j)^{th}$ combinations with $i + j \leq n + 1$ is used to construct estimates for future payments. The purpose of loss reserving techniques is to complete the run-off triangle to a square or even to a rectangle if estimates are required pertaining to development years for which there is no data at hand. Loss reserve deals with the determination of the uncertain present value of an unknown amount of future payments. The actuary can make use of a broad range of techniques to determine the expected value of future, yet unpaid, losses. Year of origin, year of development and calendar year act as explanatory variables for the observation $C_{ij}$. For $(i,j)$ combinations with $i + j \leq n + 1$, $C_{ij}$ has already been observed, otherwise it is a future observation. Next to claims actually paid, these figures can also be used to denote quantities such as loss ratios. To a large extent, it is irrelevant whether incremental or cumulative data are used when considering claims reserving in a stochastic context (Antonio et al, 2004).
Forecasting outstanding claims and setting up suitable reserves to meet these claims is an important part of the business of a general insurance company. Indeed, the published profits of these companies depend not only on the actual claims paid, but on the forecasts of the claims which will have to be paid. It is essential, therefore, that a reliable estimate is available of the reserve to be set aside to cover claims, in order to ensure the financial stability of the company and its profit and loss account. The many uncertainties involved in the payment of losses makes the estimation of the required reserves more difficult. There are a number of methods which have proved useful in practice, one of which is extensively used and is known as the chain ladder technique. This is based on an algorithm which makes a point estimate of future claims. The chain-ladder method is simple and logical, and is widely used in casualty insurance. Despite its popularity, there are weaknesses inherent to this method. Most importantly, it does not provide information regarding the variability of the outcome. With the processing power of today’s computers, the simplicity of the method is no longer a valid argument. All the same, the chain-ladder method is frequently used by actuaries. However, it has become evident that there is a need for better ways not only to estimate the reserves, but also to obtain some measures of their variability, as well as information on their overall probable future behavior. This has led to the development of stochastic reserving models (Taylor, 2000; England and Verrall, 2002).
Methods used to estimate the necessary reserve provisions are usually classified as deterministic or non-stochastic and statistical or stochastic (Hossack et al, 1999; Taylor, 2000). Different statistical approaches for dealing with the problem have been developed in recent years. These methods attempt to find a consistent claim run-off pattern which has applied in the past; assume that pattern is stable and that it will continue to hold, and then apply that pattern to estimate the claims that have been incurred but are still outstanding. However, mechanical application of any statistical method does not lead to a correct result, and the result obtained will often need to be heavily qualified.

3.2 Literature Review:

The most venerable and most famous of loss reserving methods are certainly the chain-ladder method and the basic idea of the chain-ladder method is known to Tarbell (1934). The chain-ladder method proposes predictors of the ultimate (cumulative) losses and every predictor is obtained sequentially by multiplying the current (cumulative) loss by the chain ladder factors which are certain development factors (or link ratios) obtained from the runoff triangle.

The stochastic chain ladder method (Kremer, 1982) considers the multiplicative case. Kremer derives the normal equations for the chain ladder linear model and also examined the relationship between the linear model and the crude chain ladder technique. He shows that the chain ladder technique is equivalent to applying a two-way analysis of variance model to the logged incremental claims. For a further discussion of the use of main stream statistical theory applied to the
least squares estimation of the linear model which is close to the chain ladder method, the reader is referred to Renshaw (1989). The relationship between this log-linear model and the chain-ladder technique is first pointed out by Kremer (1982) and used by Renshaw (1989), Verrall (1989) and Christofides (1990), among others. Using this model gives not exactly the same predictions as those obtained by the chain-ladder technique. Other models which can be cast in the log-linear form include the Gamma curve run-off (Zehnwirth, 1985), and the exponential tail (Ajne, 1989).

Improvements to the chain-ladder method have been made through the development of stochastic models which support the chain-ladder technique (England and Verral, 2002; Hess and Schmidt, 2002; Neuhaus, 2006; Renshaw and Verral, 1998). Prediction errors can be obtained when a stochastic model is used, allowing greater knowledge of the reserve estimate. When finding a stochastic model that reproduces chain-ladder estimates, some assumptions must be made about the insurance claims. It is possible either to specify the distribution of the insurance claims, or merely state the two first moments (England and Verral, 2002). The Poisson distribution may be appropriate when events are to be counted during an interval. During an insurance period accidents occur and claims are made. A number of authors propose a Poisson model in this situation (Hess and Schmidt, 2002; Renshaw and Verral, 1998; Verral, 2000). Other distributions are closely linked to the Poisson distribution are the negative binomial distribution, the multiplicative distribution etc (England and Verral, 2002). In contrast to the
Poisson and negative binomial model, the multiplicative model only specify the first two moments. The Poisson model can be viewed as a special case of the multiplicative model. It has the same basic multiplicative structure of the first moment, but in addition a Poisson distribution of the incremental claims is assumed. Verral (2000) claimed that the Poisson model will produce exactly the same reserve estimates as the chain-ladder method. This is true when maximum likelihood estimators (MLE) are used. Neuhaus (2006) states that if the incremental claim, conditioned on the development up to year \((j - 1)\) is distributed as compound Poisson variables.

Distribution-free approach (Mack, 1993) extends the basic chain ladder method so that formalized estimates of the reserving can be calculated. This method for estimating reserve is based on the three basic assumptions which can be use to derive formulae for mean square error (MSE) of the reserve estimate for each year of origin as well as total reserve. He shows that the estimate of developing factor calculated using chain ladder method is unbiased. He also suggests the unbiased estimator MSE of the reserve estimate for each year of origin as well as total reserve. Murphy (1993) has modified the Mack's (1993) model. The distribution-free method is developed in order to estimate the prediction of chain ladder reserve estimates.

3.3 Objectives of Study:

The choice of a model or of a method of prediction is a choice which has to be made by actuary based on data at hand and which may have considerable impact
on the result. Distribution-free approach to chain ladder (DFCL) introduced by Mack (1993) (detail given in section 3.4) has been applied for this study. This chapter proposes a few alternative methods to extend the distribution-free chain ladder method given by Mack to estimate the future payments. A comparative study in respect of standard error has also been made between DFCL and proposes methods using secondary data of automobile insurance of the NIACL.

3.4 Methods and Materials of the Study:

The basic chain ladder method most widely uses reserving method. The chain ladder method was the first of the run-off techniques to be developed. It is the simplest of all the models that can be used and it is based on the assumption that there is a consistent delay pattern in the payment of claims. This method is also known as link ratio method. The method is very simple and it is based on the assumption that proportionate relationships experienced between values in successive develop periods in the past will repeat in the future. This method is deterministic in nature. The ratios of the following values in one row are approximately constant independently on accident period ‘i’ (but depend on development period ‘j’) i.e.,

\[
C_{i,j+1} = C_{i,j} \times f_j, \quad i = 1, 2, 3, \ldots \ldots \ldots, n
\]

\[
j = 1, 2, 3, \ldots, (n-1)
\]

The most conventional estimate of \( f_j \) is
The ultimate claims amount in year ‘i’ is

\[ \hat{C}_{t,n} = \hat{C}_{t,n-i+1} \prod_{j=n-i}^{n-1} \hat{f}_j, \quad i = 2, \ldots, n. \]  

(3.2)

And the corresponding outstanding reserve for the year ‘i’ is

\[ \hat{R}_i = \hat{C}_n - C_{t,n-i+1}, \quad i = 2, \ldots, n. \]  

(3.3)

The total reserve be

\[ \hat{R} = \sum_{i=2}^{n} \hat{R}_i \]  

(3.4)

\( \hat{f}_j \) is the weighted volume development factor for development year \( j \) to \( j+1 \).

The deterministic model underlying the basic chain ladder method can be expressed as

\[ C_y = s_i r_j + \varepsilon_y \]

where, \( s_i \) represents ultimate level of claims for the year of origin \( i \), \( r_j \) is the proportion of the ultimate that has emerged by the end of \( j^{th} \) development period and \( \varepsilon_y \) is an error term. This model combines a “development year effect” with “year of origin effect”.

In the basic chain ladder, the \( r_j \) are derived using weighted averages of the ratios of cumulative values of claims in successive development periods. The
methodology can also be applied to incremental values, but this is not usually the
case since the amounts tend to reduce as a period of origin matures and the ratio in
successive years becomes unstable.

The method assumes that the cumulative position at development period \( j \) is
the most appropriate basis to estimate the accumulated position at development
period \( j +1 \) and, by deduction, the incremental movement from period \( j \) to period \( j +1 \).

**Distribution-Free Approach (DFCL)** (Mack, 1993) extends the basic
chain ladder method so that formalized estimates of the reserving can be calculated.
This method for estimating reserve is based on the following three assumptions
which can be shown to underlie the chain ladder method:

\[
(i) \quad E(C_{i,j+1}/C_{i,j}, \ldots, C_{n,j}) = C_{j} \times f_{j} \quad ; 1 \leq i \leq n \text{ and } 1 \leq j \leq n-1
\]

\[
(ii) \quad (C_{1,j}, \ldots, C_{i,j}) \text{ and } (C_{j,j}, \ldots, C_{n,j}) \text{ are independent, for } i \neq j
\]

\[
(iii) \quad \text{Var}(C_{i,j+1}/C_{i,j}, \ldots, C_{n,j}) = C_{j} \times \sigma_{j}^{2} \quad ; 1 \leq i \leq n \text{ and } 1 \leq j \leq (n-1)
\]

where, \( \sigma_{j}^{2} \) is the variance components parameter.

Mack (1993) considers the model to be distribution-free, since the full
distribution of the underlying data is not specified. This simplifies the model but it
limits analysis of the distribution of outstanding reserves to the first two moments
only. If the results are used in a dynamic financial analysis exercise, where the
distribution of outstanding reserves might be simulated, further assumptions are
necessary.
Since the reserve required $R_i$, say, for the period of origin "i", is just a function of claim amounts

$$\hat{R}_i = \hat{C}_{in} - C_{i,n-i+1}, \quad i=2,\ldots,n$$

It is possible to use the three assumptions above to derive formulae for mean square error (MSE) of the reserve estimate for each year of origin. Mack (1993) shows that the estimate of parameter $f_j$ calculated using chain ladder method is unbiased. He also suggests the unbiased estimator of $\sigma_j^2$, MSE of $R_i$ and MSE of $R$ (total reserve).

$$\hat{\sigma}_j^2 = \frac{1}{n-j-1} \sum_{i=1}^{n-j} C_y \left( \frac{C_{i,n-i+1}}{C_y} - \hat{f}_j \right)^2 ; \quad 1 \leq j \leq (n-2) \quad (3.6)$$

If $\hat{f}_{i-1} = 1$ and if the claims development is believed to be finished after $(i-1)$ years, we can put $\hat{\sigma}_{i-1} = 0$. Otherwise,

$$\hat{\sigma}_{i-1}^2 = \min \left( \hat{\sigma}_{i-2}^4, \hat{\sigma}_{i-2}^2, \min(\hat{\sigma}_{i-3}^2, \hat{\sigma}_{i-2}^2) \right) \quad (3.7)$$

$$MSE(\hat{R}_i) = \hat{C}_y \sum_{j=n+1-i}^{n-1} \frac{\hat{\sigma}_j^2}{\hat{f}_j} \left( \frac{1}{\hat{C}_y} + \frac{1}{\sum_{k=1}^{n-j} C_{kj}} \right) \quad (3.8)$$

where, $\hat{C}_y = C_{i,n+1-i}, \hat{f}_{n+1-i}, \ldots, \hat{f}_{n-i}; j > (n+1-i)$ are the estimated values of future $C_y$ and $\hat{C}_{i,n+1-i} = C_{i,n+1-i}$.

$$MSE(\hat{R}) = \sum_{i=2}^{n} \{ MSE(\hat{R}_i) + \hat{C}_m \left( \sum_{k=i+1}^{n} \hat{C}_{kn} \right) \sum_{j=n+1-i}^{n-1} \frac{2\hat{\sigma}_j^2}{\hat{f}_j} \left( \frac{1}{\sum_{k=1}^{n-j} C_{kj}} \right) \} \quad (3.9)$$
The formula uses only the data from the chain ladder triangle, and the development factors and reserve calculated using the method. The regression model has been introduced to estimate the future payments in the Mack model (Booth et al, 2005) is

\[ C_{i,j+1} = C_y f_j + \varepsilon \]

where, \( \text{var}(\varepsilon) = C_y \sigma_j^2 \). This suggests that the incremental claims in period \( j \) are a fixed proportion of the cumulative claims up to period \( j \). The distribution-free method is developed in order to estimate the prediction errors of chain ladder reserve estimates.

**Proposed Estimators for \( f_j \):**

The estimate, which is mentioned earlier, for \( f_j \) is actually the proportion of two Arithmetic Means (AM) i.e.,

\[ \hat{f}_j(AM) = \frac{\sum_{m=1}^{n-j} C_{i,j+1}}{\sum_{m=1}^{n-j} C_{i,j}}/(n-j) = \frac{\text{AM of Series } C_{i,j+1}'}{\text{AM of Series } C_y'} \]

Henceforth, we denote DFCL method by DFCL(AM) method.

Now in addition to the assumptions made in (3.5) by Mack, propose methods for estimating reserve are based on the following assumptions:

- (a) \( E(C_{i,j+1}/C_{ih}, \ldots, C_y) = C_y f_j^\beta ; 1 \leq i \leq n, 1 \leq j \leq n - 1 \) and \( \beta \) is any real number.
- (b) \( \{C_{ih}, \ldots, C_m\} \) and \( \{C_{jh}, \ldots, C_m\} \) are independent, for \( i \neq j \).
- (c) \( E(\hat{f}_j^\beta) = f_j^\beta \), then the estimators \( \hat{f}_j, 1 \leq j \leq n - 1 \), are unbiased for \( f_j \).
Here, it is proposed to replace AM of equation (3.10) by QM (Quadratic Mean) and GM (Geometric Mean), then

\[
\hat{f}_j(QM) = \sqrt{\frac{\sum_{i=1}^{n-j} C_{i,j+1}^2}{(n-j)}} = \frac{\text{QM of Series } C_{t,j+1}'}{\text{QM of Series } C_y'} \quad (3.12)
\]

\[
\hat{f}_j(GM) = \left(\frac{\prod_{i=1}^{n-j} C_{i,j+1}}{\prod_{i=1}^{n-j} C_y}\right)^{\frac{1}{n-j}} = \frac{\text{GM of Series } (j+1)}{\text{GM of Series } j} \quad (3.13)
\]

Based on the assumptions made in (3.11), the form of the expressions for the equations (3.2) to (3.4) and (3.6) to (3.9) remain unchanged but one have to replace \(\hat{f}_j(AM)\) by \(\hat{f}_j(QM)\) and \(\hat{f}_j(GM)\) and these methods for estimating reserve be termed as DFCL(QM) and DFCL(GM) methods respectively.

### 3.5 Data Description:

The motor insurance paid claims in two ways. They are (1) paid claims for motor own damage and (2) paid claims for motor third party liability. But here data have considered these cases without separation. The payments in the period might be subdivided into payments on previously existing claims or payments on newly advised claims. These values would normally be available by reference to a period of origin and a calendar period of transaction. The origin period is the opening reference point for a claims cohort and is commonly an accident or underwriting period.
The data set at hand for claims paid upon which projections of future reserves are collected from the regional office of The New India Assurance Company Limited, Guwahati. This regional office of NIACL, Guwahati comprised mainly eight divisional offices. These divisional offices are Dibrugarh, Guwahati-I, Bangaigon, Shillong, Dimapur, Silchar, Guwahati-II and Tinsukia. These divisional offices cover insurance of all the eight North-Eastern States (Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikim) of Indian Territory. The paid claims of all eight divisions have been considered together.

The Table 3.2 represents the mid-year data on claim paid. The company pays amounts Rs.2603L, Rs.1532L, Rs.668L, Rs.76L, Rs.1L (L used for lakh) in the years 2004, ..., 2008 respectively for the claims arising out from motor insurance in the year 2004. Similarly, payments of amounts Rs.2472L, Rs.1807L, Rs.635L, Rs.55 are given in years 2005, ..., 2008 respectively for the claims arising out in the year 2005. Again, payments of amount Rs.3018L, Rs.1985L, Rs.608L are given in years 2006, ..., 2008 respectively for the claims arising out in the year 2006 and Rs.3744L & Rs.2138L are given in years 2007 & 2008 respectively for the claims arising out in the year 2007. Finally, Rs.3988 pays in the year 2008 for the claims arising out in the year 2008 itself (Table 3.2).

3.6 Results and Discussion:

The Table 3.3 and Table 3.4 have shown the development factors and the reserves using the methods DFCL(AM), DFCL(GM) and DFCL(QM) for the years 2005, ..., 2008 and the overall reserves. The reserves using DFCL(AM),
DFCL(GM) and DFCL(QM) give very similar estimates. In the year 2005, the estimated value of factor $\hat{f}_4$ (Table 3.3) are equal all in DFCL(AM), DFCL(GM) and DFCL(QM) methods, because when the number of observation be single then AM, GM and QM are equal. Hence the estimated reserves using the methods DFCL(AM), DFCL(GM) and DFCL(QM) for the years 2005 (Table 3.4) also equal here. In the year 2006, the estimated value of factor $\hat{f}_3$, all in DFCL(AM), DFCL(GM) and DFCL(QM) methods are equal (up to four decimal places). So the cumulative development factors and the estimated reserves are also equal in all cases. In the years 2007 and 2008, the development factors $\hat{f}_2$ and $\hat{f}_1$ respectively in DFCL(AM) show higher values than DFCL(QM) and DFCL(GM) higher than DFCL(QM). Hence the reserves are provided accordingly. The total estimated reserves using DFCL(AM), DFCL(GM) and DFCL(QM) for the coming year 2009 are 5958 lakhs, 6014 lakhs and 5896 lakhs respectively.

The standard error (SE) or percentage of standard error (PSE) (Table 3.4) of reserves in all methods (DFCL(AM), DFCL(GM) and DFCL(QM)) approximately equal. But DFCL(QM) shows slightly lower or equal SE or PSE of reserves almost in all years (except 2007) as well as in overall reserves than DFCL(AM) and DFCL(GM) provides less than or equal values than DFCL(QM). In origin year 2005, the PSE are very high in all cases because the reserves $\hat{R}_2$ itself is very low in comparison to other reserves $\hat{R}_3$, ..., $\hat{R}_5$. Looking at the sequences $\hat{R}_2$, ..., $\hat{R}_4$, $\hat{R}_5$ and its SE, it is seen that both reserves and SE are increasing. But the PSE are
gradually decreased with increment of reserve amounts. The overall PSE in DFCL(AM), DFCL(QM) and DFCL(GM) are 7.47, 7.40 and 7.28 respectively. As such DFCL(GM) provides optimum results.

The percentage deviation of experience from expectation (Table 3.4) of reserves in all methods (DFCL(AM), DFCL(GM) and DFCL(QM)) approximately equal. The percentage deviation of experience from expectation in DFCL(AM) method be 6.40% which is slightly higher than that of DFCL(QM) method (6.34%) and similarly DFCL(GM) provides relatively higher value (6.51%) than DFCL(AM) (Table 3.4). As such DFCL(QM) provides optimum results among these methods.

The estimates of the development factors in the chain ladder technique can be reformulated by substituting arithmetic mean by quadratic mean as well as geometric mean. The DFCL(QM) and DFCL(GM) can be an effective method of estimating the reserves in the incremental run-off triangle. All the DFCL(AM), DFCL(QM) and DFCL(GM) techniques produce a very similar estimates but the DFCL(QM) as well as DFCL(GM) methods somewhat better than DFCL(AM) method in terms of percentage of standard error and percentage deviations of experience from expectations both these data sets. The propose methods can be validated through application to other datasets.
Table 3.1: Random variables in run-off triangle

<table>
<thead>
<tr>
<th>Year of origin i</th>
<th>Development year (j)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>$C_{11}$</td>
</tr>
<tr>
<td>2</td>
<td>$C_{21}$</td>
</tr>
<tr>
<td>3</td>
<td>$C_{31}$</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>n</td>
<td>$C_{n1}$</td>
</tr>
</tbody>
</table>

$C_0$: the total claims figure for year of origin i and development year or year of payment j.
Table 3.2: Run-off triangle of incremental claim paid (in Rs. Lakh)

<table>
<thead>
<tr>
<th></th>
<th>Development Year (j)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2004</td>
<td>2603</td>
<td>1532</td>
<td>668</td>
<td>76</td>
<td>1</td>
</tr>
<tr>
<td>2005</td>
<td>2472</td>
<td>1807</td>
<td>635</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>3018</td>
<td>1985</td>
<td>608</td>
<td></td>
<td></td>
</tr>
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<td>2007</td>
<td>3744</td>
<td>2138</td>
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</tr>
<tr>
<td>2008</td>
<td>3988</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3.3: Developments factors of incremental claim payments

<table>
<thead>
<tr>
<th>Developing Periods (in years)</th>
<th>1 - 2</th>
<th>2 - 3</th>
<th>3 - 4</th>
<th>4 - 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing Factors ($f_i$)</td>
<td>$\hat{f}_1$</td>
<td>$\hat{f}_2$</td>
<td>$\hat{f}_3$</td>
<td>$\hat{f}_4$</td>
</tr>
<tr>
<td>Ratio (Using AM)</td>
<td>1.6304</td>
<td>1.1424</td>
<td>1.0135</td>
<td>1.0002</td>
</tr>
<tr>
<td>Developing Periods</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cumulative Factors (AM)</td>
<td>1.8882</td>
<td>1.1581</td>
<td>1.0137</td>
<td>1.0002</td>
</tr>
<tr>
<td>Ratio (Using GM)</td>
<td>1.6359</td>
<td>1.1437</td>
<td>1.0135</td>
<td>1.0002</td>
</tr>
<tr>
<td>Developing Periods</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cumulative Factors (GM)</td>
<td>1.8966</td>
<td>1.1594</td>
<td>1.0137</td>
<td>1.0002</td>
</tr>
<tr>
<td>Ratio (Using QM)</td>
<td>1.6245</td>
<td>1.1411</td>
<td>1.0135</td>
<td>1.0002</td>
</tr>
<tr>
<td>Developing Periods</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cumulative Factors (QM)</td>
<td>1.8791</td>
<td>1.1567</td>
<td>1.0137</td>
<td>1.0002</td>
</tr>
</tbody>
</table>
Table 3.4: Standard errors of estimated reserves for claim payments

<table>
<thead>
<tr>
<th>Origin Year (i)</th>
<th>DFCL(AM)</th>
<th>DFCL(GM)</th>
<th>DFCL(QM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\hat{R}$, s.e.$(\hat{R})$ / $\hat{R}$*100%</td>
<td>$\hat{R}$, s.e.$(\hat{R})$ / $\hat{R}$*100%</td>
<td>$\hat{R}$, s.e.$(\hat{R})$ / $\hat{R}$*100%</td>
</tr>
<tr>
<td>2005</td>
<td>1, 3.76057, 376.06</td>
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<td>78, 21.88174, 28.05</td>
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<td>1025, 127.99315, 12.49</td>
<td>1032, 133.28122, 12.91</td>
<td>1016, 133.29649, 13.12</td>
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<td>4854, 407.25246, 08.39</td>
<td>4903, 397.64108, 08.11</td>
<td>4801, 396.21568, 8.25</td>
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<td>Overall</td>
<td>5958, 444.83492, 07.47</td>
<td>6014, 437.79357, 07.28</td>
<td>5896, 436.34925, 7.40</td>
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<tr>
<td>% Deviation of experience from expectation</td>
<td>6.40</td>
<td>6.51</td>
<td>6.34</td>
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