ISBN : 978-979-17979-0-0

Prosiding

Seminar Nasional Mahasiswa S3 Matematika

REVITALISASI DAN SOSIALISASI DIRI UNTUK BERPERAN AKTIF DALAM PENINGKATAN KUALITAS PENELITIAN & PENDIDIKAN MATEMATIKA DI INDONESIA

Editor :
Muslim Ansori
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Hasih Pratiwi

Forum Komunikasi Mahasiswa S-3 Matematika se-Indonesia
Bekerja Sama Dengan Jurusan Matematika FMIPA UGM

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PROSIDING SEMINAR NASIONAL

MAHASISWA S3 MATEMATIKA INDONESIA 2008

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KATA PENGANTAR

Puji syukur kami panjatkan kehadirat Allah SWT atas terselenggarakannya Seminar Nasional Mahasiswa S3 Matematika Indonesia pada tanggal 31 Mei 2008 di Jurusan Matematika FMIPA UGM Yogyakarta. Kegiatan ini merupakan kegiatan ilmiah rutin yang diadakan oleh Forum Komunikasi Mahasiswa S3 Matematika Indonesia sejak tahun 2005.

Seminar Nasional ini diselenggarakan dengan tujuan (1) memberikan wawasan dan berbagi informasi diantara mahasiswa matematika/statistika dan pendidikan matematika, atau peminat matematika tentang hasil penelitian yang telah atau sedang dilakukan; (2) mendorong terciptanya kerjasama keilmuan antara mahasiswa S3 matematika/satistika dan pendidikan matematika, atau antara mahasiswa S3 matematika/statistika/pendidikan matematika dengan para pakar matematika/statis-tika/pendidikan matematika lainnya di Indonesia; dan (3) membentuk korps keilmuan untuk pengembangan profesi ke depan dan menjalin silaturahmi antara sesama mahasiswa dan alumni S3 matematika/statistika/pendidikan matematika se-Indonesia.

Peserta yang berpartisipasi dalam kegiatan ini berjumlah 90 orang yang berasal dari berbagai institusi/instansi, yaitu ITB, UNY, UPI, UT, UNMER Malang, UNMUL, UNNES, UM, IPB, UNIMED, USD, ITS, UNSOED, UNTAD, IAIN Antasari Banjarsari, UNISBA, Universitas Widya Dharma Klaten, UNESA, SMA Sang Timur Yogyakarta, UBAYA, Universitas Veteran Bangun Nusantara Sukoharjo, UNIKA Parahyangan, UNTAD, Universitas Mahasaraswati, UI, UII, UNPAD, STAIN Purwokerto, UNHALU, UNSRAT, Universitas PGRI Palembang, UNCEN, UNPAD, STKIP YASIKA Majalengka, UNEJ, STKIP PGRI Pontianak, UIN Syarif Hidayatullah, UNPATI, STT Garut, UNILA, Universitas Negeri Gorontalo, SMKN 2 Ygyakarta, BATAN, UBINUS, Universitas Muhammadiyah Bengkulu, UNAND, SKIP Siliwangi Bandung, Sekolah Tinggi Sandi Negara, dan UGM. Di antara peserta ini, yang membawakan makalah berjumlah 50 orang. Pembicara utama pada seminar ini adalah Prof. Dr. Muchlas Samani (Direktur Ketenagaan Ditjen Dikti Depdiknas) dan Dr. Supama, M.Si. (Peneliti Bidang Analisis Jurusan Matematika FMIPA Universitas Gadjah Mada).

Terselenggaranya Seminar Nasional ini tidak lepas dari dukungan berbagai pihak. Untuk itu terima kasih kami sampaikan kepada peserta Seminar Nasional atas partisipasinya yang aktif serta kepada Fakultas MIPA UGM dan Jurusan Matematika FMIPA UGM atas fasilitas dan dukungan dananya. Ucapan terima kasih juga kami sampaikan kepada Forum Komunikasi Mahasiswa S3 Matematika Indonesia atas dukungan dan publikasinya. Terakhir, terima kasih juga kami sampaikan kepada rekan-rekan Panitia dan staf Jurusan Matematika FMIPA UGM atas dukungan dan kerjasamanya sehingga Seminar Nasional ini dapat terselenggara dengan lancar.

Yogyakarta, Mei 2008

Ketua Panitia

SAMBUTAN :
PENGELOLA S2/S3 MATEMATIKA FMIPA UGM

Yang terhormat Dekan Fakultas MIPA,
Yang terhormat Direktur Ketenagaan Ditjen Dikti Depdiknas,
Yang terhormat Staf Pengajar S3 Matematika FMIPA UGM,
Yang terhormat Hadirin Peserta Seminar Nasional,
Assalamu 'alaikum Warahmatullaahi Wabarakaatuh,

Selamat pagi dan salam sejahtera bagi kita semua.
Pertama-tama marilah kita memanjatkan puji dan syukur kehadirat Tuhan Yang Maha Kuasa karena atas perkenan-Nya kita dapat berkumpul pada acara seminar yang penting ini, yaitu *Seminar Nasional Mahasiswa S3 Matematika se-Indonesia.* Kami menyambut baik acara yang diprakarsai dan diselenggarakan oleh mahasiswa S3 Matematika karena dapat mendorong terciptanya kerjasama keilmuan antara mahasiswa S3 Matematika/Satistika dan Pendidikan Matematika, atau antara mahasiswa S3 Matematika/Statistika/Pendidikan Matematika dengan para pakar Matematika/Statistika/Pendidikan Matematika lainnya di Indonesia.

Pada kesempatan ini, kami mengucapkan selamat mengikuti rangkaian *Seminar Nasional Mahasiswa S3 Matematika se-Indonesia* yang sangat penting ini. Semoga upaya yang kita laksanakan ini dapat menghasilkan sumbangan yang berharga dan menjadi bekal bagi kita semua dalam mencapai masyarakat Indonesia yang andal, cerdas, mempunyai komitmen moral dan semangat pengabdian.

Lebih jauh lagi, kami mengharapkan Seminar Nasional ini dapat memberikan wawasan dan berbagi informasi diantara mahasiswa Matematika/Statistika dan Pendidikan Matematika, atau Peminat Matematika tentang hasil penelitian yang telah atau sedang dilakukan.

Demikian sambutan ini kami sampaikan, atas perhatian seluruh peserta Seminar Nasional, kami ucapkan terimakasih dan semoga Tuhan Yang Maha Kuasa memberkahi seluruh upaya bersama yang terus kita lakukan ini.

Wassalamu'alaikum Warahmatullaahi Wabarakaatuh.
Yogyakarta, 31 Mei 2008

Pengelola S2/S3 Matematika FMIPA UGM

DAFTAR ISI

Makalah Bidang Statistika

Malakah Bidang Terapan

Chain Ladder Method as a Gold Standard to Estimate Loss Reserves

Aceng K. Mutaqin[1)], *Dumaria R. Tampubolon*[2)], *Sutawanir Darwis*[2)]

Abstract

This paper review the chain ladder method to estimate loss reserves in general insurance and standard error of chain ladder reserve estimates that formulated by Mack (1993). The example to illustrate the method is also given. The authors provide a MATLAB program to implement the method.

Key words: *run-off triangle data, loss reserves, chain ladder method, MATLAB program*

1. Introduction

The correct estimation of the amount of money an insurance company should set aside to meet claims that arise in the future on written policies represents an important task for the insurance company. This estimation is often named as the loss reserve (or claim resereve). An insurance company needs to hold loss reserve because the timing of premiums receipt and claims payment do not coincide. There is the delay between the claim event and the claim settlement date. It could take a long time from the loss event to the reporting of the loss to the company, or it could take a long time from the day of reporting until the company knows tne ultimate cost of the claim.

In the end of every reporting period (usually year and/or quarter) the insurance company should present in the accounting how much of the money that is allocated for this incurred but not settled loss. It is necessary for business planning, budgeting and product pricing (Olofsson, 2006).

The problem of how to calculate the loss reserve is usually solved with statistical methods. Since the amount and timing of future claims are unknown, this creates an uncertainty over the amount of reserves that is necessary. The degee of uncertainty depends on the class of business written, where we have short-tail and long-tail classes (Olofsson, 2006). A short-tail

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class is a business where the delay between the occurrence of a claim and the settlement is short, often less than a year, such as motor insurance that, for example, covers fire and theft (Olofsson, 2006). A long-tail business is a business where the delay between the occurrence of a claim and it being settle is long, more than couple of years, such as motor TPL (third party liability) that covers personal injury (Olofsson, 2006), and marine insurance (Hertig, 1985).

It is common to estimate loss reserve for long-tail business based on run-off triangle data (for example, see De Jong, 2006; England, dan Verrall, 2002; Verrall, 2002; Mack, 1993; Pinheiro, E Silva, dan Centeno, 2003; De Alba, 2006; Panning, 2004; dan Olofsson, 2006). Run-off triangle data provides a summary of underlying data set with individual claim figures (Antonio, Beirlant, Hoedemakers, dan Verlaak, 2006). There are different statistical methods to estimate loss reserve based on run-off triangle data. The chain ladder method is probably the most popular one for estimating loss reserve. The main reason for this is its simplicity and the fact that it is distribution-free. It is frequently used as a gold standard (benchmark) because of its generalized use an ease to apply. This method is deterministic and we only get a point estimate.

Is it well-known that chain ladder reserve estimates are very sensitive to variations in the data observed (Mack, 1993). Therefore it would be very helpful to know the standard error of the chain ladder reserve estimates as a measure of the uncertainty contained in the data. Mack (1993) developed a very simple formula and distribution-free for the standard error of chain ladder reserve estimates. This paper review the chain ladder method and standard error of chain ladder reserve estimates that formulated by Mack (1993).

The remainder of the paper is structured as follows. Section 2 presents the chain ladder method to estimate loss reserve. The standard error of the chain ladder reserve estimates that formulated by Mack (1993) is discussed in Section 3. Section 4 provides an example to illustrate the method. The implementation of the method in MATLAB program are given in Section 5.

2. Chain Ladder Method

Let C_{ij} denote the cumulative total claims amount of accident year i, $1 \le i \le n$, paid up to development year j, $1 \le j \le n$. The cumulative total claims amount C_{ij} have been observed for $i + j \le n + 1$ (run-off triangle data), the other amounts, especially the ultimate claims amount C_{in}, $i > 1$, have to be predicted. The aim is to estimate the the ultimate claims amount and the outstanding claims reserve

$$R_i = C_{in} - C_{i,n+1-i}\text{; for accident year } i = 2, \ldots, n \tag{1}$$

Run-off triangle data are presented in Table 1.

Table 1 Run-off Triangle Data

Accident Period	***Development Period***						
	1	2	...	j	...	$n-1$	n
1	C_{11}	C_{12}	...	C_{1j}	...	$C_{1,n-1}$	C_{1n}
2	C_{21}	C_{22}	...	C_{2j}	...	$C_{2,n-1}$	
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\iddots$		
i	C_{i1}	C_{i2}	...	C_{ij}			
$\vdots$	$\vdots$	$\vdots$	$\iddots$				
$n-1$	$C_{n-1,1}$	$C_{n-1,2}$					
n	$C_{n,1}$						

The total reserve is

$$R = \sum_{i=2}^{n} R_i \tag{2}$$

The basic assumption of the chain ladder method is that there are development factors $f_1, \ldots, f_{n-1} > 0$ with $E(C_{i,j+1}|C_{i1}, \ldots, C_{ij}) = C_{ij}f_j$, $1 \le i \le n$, $1 \le j \le n-1$.

The chain ladder method consists of estimating the f_k by

$$\hat{f}_j = \frac{\sum_{k=1}^{n-j} C_{k,j+1}}{\sum_{k=1}^{n-j} C_{k,j}}\text{; for } 1 \le j \le n-1, \tag{3}$$

and the ultimate claims amount C_{in}, by

$$\hat{C}_{in} = C_{i,n+1-i}\hat{f}_{n+1-i}\cdot\dots\cdot\hat{f}_{n-1} \tag{4}$$

or equivalently the reserve R_i by

$$\begin{aligned}\hat{R}_i &= \hat{C}_{in} - C_{i,n+1-i} \\ &= C_{i,n+1-i}(\hat{f}_{n+1-i}\cdot\dots\cdot\hat{f}_{n-1} - 1)\end{aligned} \tag{5}$$

Because the chain ladder method does not take into account any dependencies between accident years, Mack (1993) added assumption that the variables C_{ij} of different accident years, i.e. $\{C_{i1}, \dots, C_{in}\}$, $\{C_{k1}, \dots, C_{kn}\}$, $i \neq k$, are independent. This must be regarded as a further implicit assumption of the chain ladder method.

Mack (1993) proved that

1. $E(C_{in} \mid D) = C_{i,n+1-i}f_{n+1-i}\cdot\dots\cdot f_{n-1}$, where $D = \{C_{ij} | i + j \leq n + 1\}$ is the set of all data observed so far.
2. The estimators $\hat{f}_j$, for $1 \leq j \leq n - 1$, are unbiased and uncorrelated of f_j.
3. The estimators $\hat{C}_{in} = C_{i,n+1-i}\hat{f}_{n+1-i}\cdot\dots\cdot\hat{f}_{n-1}$, for $2 \leq i \leq n$, are unbiased of $E(C_{in} \mid D) = C_{i,n+1-i}f_{n+1-i}\cdot\dots\cdot f_{n-1}$.
4. The reserve estimators $\hat{R}_i = \hat{C}_{in} - C_{i,n+1-i}$, for $2 \leq i \leq n$, are unbiased of the true reserves $R_i = C_{in} - C_{i,n+1-i}$.

3. Standard Error of Chain Ladder Reserve Estimates

The mean squared error of the estimator $\hat{C}_{in}$ of C_{in} is defined to be

$$mse(\hat{C}_{in}) = E((\hat{C}_{in} - C_{in})^2 \mid D)$$

where $D = \{C_{ij} | i + j \leq n + 1\}$ is the set of all data observed so far.

The mean squared error of the estimator $\hat{R}_i$ of R_i is

$$\begin{aligned}mse(\hat{R}_i) &= E((\hat{R}_i - R_i)^2 \mid D) \\ &= E((\hat{C}_{in} - C_{in})^2 \mid D) \\ &= mse(\hat{C}_{in}) \\ &= Var(C_{in} \mid D) + (E(C_{in} \mid D) - \hat{C}_{in})^2\end{aligned}$$

which shows that the mean squared error is the sum of the stochastic error (process variance) and of the estimation error.

Mack (1993) introduced an assumption that

$$Var(C_{i,j+1} \mid C_{i1}, \cdots, C_{ij}) = C_{ij}\sigma_j^2,\ 1 \le i \le n,\ 1 \le j \le n-1,$$

with unknown parameters σ_j^2, $1 \le j \le n-1$. This is the variance assumption which is implicitly underlying the chain ladder method.

The parameters σ_j^2, $1 \le j \le n-1$, are estimated by

$$\hat{\sigma}_j^2 = \frac{1}{n-j-1}\sum_{i=1}^{n-j} C_{ij}\left(\frac{C_{i,j+1}}{C_{ij}} - \hat{f}_j\right)^2,\ 1 \le j \le n-2. \tag{6}$$

If $\hat{f}_{n-1} = 1$ and if the claims development is believed to be finished after $n-1$ years, then $\hat{\sigma}_{n-1} = 0$, otherwise

$$\hat{\sigma}_{n-1} = \min(\hat{\sigma}_{n-2}^4 / \hat{\sigma}_{n-3}^2, \min(\hat{\sigma}_{n-3}^2, \hat{\sigma}_{n-2}^2)) \tag{7}$$

Mack (1993) proved that

1. The mean squared error $mse(\hat{R}_i)$ can be estimated by

$$\widehat{mse(\hat{R}_i)} = \hat{C}_{in}^2 \sum_{j=n+1-i}^{n-1} \frac{\hat{\sigma}_j^2}{\hat{f}_j^2}\left(\frac{1}{\hat{C}_{ij}} - \frac{1}{\sum_{k=1}^{n-j} C_{kj}}\right) \tag{8}$$

   where $\hat{C}_{ij} = C_{i,n+1-i}\hat{f}_{n+1-i} \cdot \cdots \cdot \hat{f}_{j-1}$, $i + j > n + 1$, are the estimated values of the future C_{ij} and $\hat{C}_{i,n+1-i} = C_{i,n+1-i}$.

2. The mean squared error of the total reserve estimate $\hat{R}$ can be estimated by

$$\widehat{mse(\hat{R})} = \sum_{i=2}^{n}\left\{[se(\hat{R}_i)]^2 + \hat{C}_{in}\left[\sum_{k=i+1}^{n}\hat{C}_{kn}\right]\sum_{j=n+1-i}^{n-1}\frac{2\hat{\sigma}_j^2 / \hat{f}_j^2}{\sum_{m=1}^{n-j} C_{mj}}\right\} \tag{9}$$

   where $se(\hat{R}_i)$ is the standard error of $\hat{R}_i$, i.e. the squared root of $mse(\hat{R}_i)$.

4. Example

In this paper, we use the data which were used by Mack (1993) in the first example to apply the chain ladder reserve estimates and its standard errors. The data are presented in Table 2.

Table 2 Run-off Triangle Data (Cumulative Figures)

i	C_{i1}	C_{i2}	C_{i3}	C_{i4}	C_{i5}	C_{i6}	C_{i7}	C_{i8}	C_{i9}	C_{i10}
1	357848	1124788	1735330	2218270	2745596	3319994	3466336	3606286	3833515	3901463
2	352118	1236139	2170033	3353322	3799067	4120063	4647867	4914039	5339085	
3	290507	1292306	2218525	3235179	3985995	4132918	4628910	4909315		
4	310608	1418858	2195047	3757447	4029929	4381982	4588268			
5	443160	1136350	2128333	2897821	3402672	3873311				
6	396132	1333217	2180715	2985752	3691712					
7	440832	1288463	2419861	3483130						
8	359480	1421128	2864498							
9	376686	1363294								
10	344014									

This yields the parameter estimates $\hat{f}_j$ and $\hat{\sigma}_j^2$, (j = 1, 2, …, 9):

Table 3 The Parameter Estimates

	$j=1$	$j=2$	$j=3$	$j=4$	$j=5$	$j=6$	$j=7$	$j=8$	$j=9$
$\hat{f}_j$	3.49061	1.74733	1.45741	1.17385	1.10382	1.08627	1.05387	1.07656	1.01772
$\hat{\sigma}_j^2$	160280	37736.86	41965.2	15182.9	13731.3	8185.77	446.617	1147.37	446.617

Table 4 shows the ultimate claims, the estimated reserves, the standard errors of the estimated reserves, and the standard errors of the estimated reserves in % of $\hat{R}_i$ for i = 2, 3, …, 10. The last row in Table 4 contains the estimated total reserve and its standard error.

Table 4 Summary of The Chain Ladder Reserve Estimates

	Ultimate Claims	**Estimated Reserves**	**Standard Errors**	**Standard Errors in % of $\hat{R}_i$**
$i=2$	5433719	94634	75535	0.80
$i=3$	5378826	469511	121699	0.26
$i=4$	5297906	709638	133549	0.19
$i=5$	4858200	984889	261406	0.27
$i=6$	5111171	1419459	411010	0.29
$i=7$	5660771	2177641	558317	0.26
$i=8$	6784799	3920301	875328	0.22
$i=9$	5642266	4278972	971258	0.23
$i=10$	4969825	4625811	1363155	0.29
	Overall	18680856	2447095	0.13

```
function out=CLM(C)
% This program is designed to implement the chain ladder method.
% The input program is C    : a matrix contains the run-off triangle data
%                             in cumulative form
% The output program is out : a matrix contains
%                             column 1: Ultimate claims
%                             column 2: Reserve estimates
%                                  (including total reserve estimate in the last row)
%                             column 3: Standard errors of reserve estimates
%                                (including for total reserve estimate in the last row)
%                             column 4: Standard errors in % of reserve estimates
%                                   (column 3/column 2)
n=size(C,1); % number of accident years/development years
m=n-1;
for j=1:m
  f(j,1)=sum(C(:,j+1))/(sum(C(:,j))-C(n+1-j,j)); % development factors
end
C1=C;
k=n+1;
for i=2:n
   k=k-1;
   for j=k:n
      C1(i,j)=C1(i,j-1)*f(j-1,1);
   end
   out(i,1)=C1(i,n);          % Ultimate Claims
   out(i,2)=C1(i,n)-C1(i,k-1); % Reserve Estimates
end
out(n+1,2)=sum(out(2:n,2));     % Total Reserve Estimate
m2=n-2;
for j=1:m2
   sigma2(j,1)=sum(C(1:n-j,j).*(C(1:n-j,j+1)./C(1:n-j,j)-f(j,1)).^2)/(n-j-1);
end
if f(n-1,1)==1
   sigma2(m2+1,1)=0;
else
   a=(sigma2(n-2,1))^2/sigma2(n-3,1);
   b=min(sigma2(n-3,1),sigma2(n-2,1));
   sigma2(m2+1,1)=min(a,b);
end
for i=2:n
   k1=n+1-i;
   k2=n-1;
   s1=0;
   for k=k1:k2
      b=sum(C1(1:n-k,k));
      s1=s1+sigma2(k,1)/f(k,1)^2*(1/C1(i,k)+1/b);
   end
   out(i,3)=sqrt(C1(i,n)^2*s1); % Standard Errors of Reserve Estimates
end
s2=0;
for i=2:n
```

```
   k1=n+1-i;k2=n-1;
   a1=sum(C1(i+1:n,n));
   a2=0;
   for k=k1:k2
      b=sum(C1(1:n-k,k));
      a2=a2+2*sigma2(k,1)/f(k,1)^2/b;
   end
   s2=s2+out(i,3)^2+C1(i,n)*a1*a2;
end
out(n+1,3)=sqrt(s2); % Standard Errors of Total Reserve Estimates
for i=2:n+1
   out(i,4)=out(i,3)/out(i,2); % Standard Errors in % of Reserve Estimates
end
```

Figure 1
MATLAB Program to Implement The Chain Ladder Method

5. Implementing the Chain Ladder Method in MATLAB

The chain ladder method can be implemented using MATLAB program (see Figure 1). This program can be used to calculate the ultimate claims, the estimated reserves, the standard errors of the estimated reserves, and the standard errors of the estimated reserves in % of the estimated reserves. The values in Table 4 are generated using the MATLAB program in Figure 1.

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Seminar Nasional
Mahasiswa S3 Matematika

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