Claims Tracking & Monitoring

A GLM and Retrospective Loss Random Variable Approach

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Outline

- Claims tracking and monitoring process
- Implications of tracking & monitoring process
- GLM approach to changing assumptions
- Application to adjusting surrender rates for variable annuities
- Retrospective loss random variable problem formulation
- Implications of retrospective loss random variable
- Application to adjusting prospective statutory reserves
- Some concluding remarks

Claims tracking and monitoring process

- Determining a set of expected claim assumptions
- Calculation actual to expected claim ratios periodically
- Identifying subsets of the inforce where actual assumptions are significantly different from expected
- Determining whether this is a one-time only occurrence or a trend shift
- Adjusting future expected assumptions to reflect trend shift

Claims tracking & monitoring – cont'd

- Usual practice is to use aggregate industry data to generate expected assumptions
- Expected assumptions are typically developed using a GLM model
- UConn actuarial science student for his Senior Honors thesis developed an algorithm to identify subsets of an inforce block with significant A/E deviations

✓ Only focused on main variables and first order interaction variables

✓Significantly speed up processing time compared to an exhaustive search

- Team of Goldenson Center students have written a paper (Risk Magazine, Dec. 2014) on this topic and how to identify a trend shift.

Implications of tracking & monitoring process

- Revise underwriting rules and marketing strategy
- Revise pricing assumptions
- Revise reserves being held

GLM approach to changing assumptions

- Adjusting expected assumptions to reflect a trend shift is the basis of PhD research of a UConn actuarial science student

➢ Assumes expected assumptions developed using a GLM framework

➢ Construct a similar GLM model using actual company experience assuming a trend shift

➢ Construct a confidence interval for each of the GLM parameters

➢ Rule: If expected GLM parameter falls within confidence band, use expected assumption. Otherwise adjust expected assumption to the nearest boundary of the confidence interval

Application to adjusting VA surrender rates

- Client data included about 628 million observations from 20 companies
- Aggregate GLM model first developed as the basis for expected assumptions
- Individual GLM models developed for each company to determine adjustments to expected assumptions

➢ Confidence interval width used a credibility formula where larger companies used a tighter CI and smaller companies used a wider CI

Retrospective loss random variable

- Retrospective loss rv = **share per survivor of the accumulated net assets per $1000 of insurance at duration t.**
- Prospective loss rv = **share per survivor of the present value of net liabilities per $1,000 of insurance at duration t.**
- Can show E(retrospective loss rv) = E(prospective loss rv)
- But SD of retrospective loss rv **does not** equal SD of prospective loss rv

Retrospective vs Prospective Reserving

	Retrospective	Prospective
Loss Random Variable	$${}_t\bar{L}^R = \begin{cases} \dfrac{\bar{P} * \bar{a}_{\overline{T}\rceil} * (1+i)^t - (1+i)^{t-T}}{{}_tp_x}, for\ T < t \\ \dfrac{\bar{P} * \bar{a}_{\overline{T}\rceil} * (1+i)^t}{{}_tp_x}, for\ T \geq t \end{cases}$$	$${}_t\bar{L}^P = \begin{cases} v^S - \bar{P} * \bar{a}_{\overline{S}\rceil}, for\ S < n-t \\ -\bar{P} * \bar{a}_{\overline{n-t}\rceil}, for\ S \geq n-t \end{cases}$$
Reserve =E(Loss Random Variable)	$$E[{}_t\bar{L}^R] = \begin{cases} \dfrac{\bar{P} * \bar{a}_{x:\overline{t}\rceil} - \bar{A}^1_{x:\overline{t}\rceil}}{v^t * {}_tp_x}, t < n \\ 0, t \geq n \end{cases}$$	$$E[{}_t\bar{L}^P] = \begin{cases} \bar{A}^1_{x+t:\overline{n-t}\rceil} - \bar{P} * \bar{a}_{x+t:\overline{n-t}\rceil}, t < n \\ 0, t \geq n \end{cases}$$
$$E[{}_t\bar{L}^R] = E[{}_t\bar{L}^P]$$		

Actuarial formulation

- Assume a fully continuous n-year term insurance policy of $1 to (x)
- The prospective loss random variable at valuation time t as the following:

$$ {}_t\bar{L}^P = \begin{cases} v^S - \bar{P} * \bar{a}_{\overline{S}|}, for\ S < n - t \\ -\bar{P} * \bar{a}_{\overline{n-t}|}, for\ S \geq\ n - t \end{cases} $$

where S is the future lifetime of (x+t)

- Note: Prospective reserve = $E[{}_t\bar{L}^P] = \begin{cases} \bar{A}^1_{x+t:\overline{n-t}|} - \bar{P} * \bar{a}_{x+t:\overline{n-t}|}, t < n \\ 0, t \geq n \end{cases}$

Actuarial formulation – cont'd

- The retrospective loss random variable at valuation time t is defined as follows:

$$ {}_t\bar{L}^R = \begin{cases} \dfrac{\bar{P} * \bar{a}_{\overline{T}|} * (1+i)^t - (1+i)^{t-T}}{{}_tp_x}, for\ T < t \\ \dfrac{\bar{P} * \bar{a}_{\overline{T}|} * (1+i)^t}{{}_tp_x}, for\ T \geq t \end{cases} $$

where T is the future lifetime of (x)

- Note: Retrospective reserve $= E[{}_t\bar{L}^R] = \begin{cases} \dfrac{\bar{P} * \bar{a}_{x:\overline{t}|} - \bar{A}^1_{x:\overline{t}|}}{v^t * {}_tp_x}, t < n \\ 0, t \geq n \end{cases}$
- Then you can show $E[{}_t\bar{L}^R] = E[{}_t\bar{L}^P]$

Example

Mean and SD of Retrospective and Prospective Loss Random Variable per 1000 for a 20 year term insurance policy of $100,000 to a male age 45

x = 45, n = 20, $M = $100,000, i=5%, Gender = M				
Duration	Retrospective RV Mean	Retrospective RV SD	Prospective RV Mean	Prospective RV SD
1	2.24	21.68	2.24	138.35
2	4.37	34.96	4.37	142.91
3	6.39	47.71	6.39	147.07
4	8.31	60.38	8.31	150.90
5	10.16	73.05	10.16	154.51
6	11.91	86.09	11.91	157.81
7	13.51	99.79	13.51	160.69
8	14.94	114.21	14.94	163.08
9	16.18	129.36	16.18	164.95
10	17.19	145.42	17.19	166.14
11	17.92	162.43	17.92	166.53
12	18.30	180.59	18.30	165.85
13	18.26	200.01	18.26	163.81
14	17.76	220.68	17.76	160.18
15	16.71	242.77	16.71	154.42
16	14.95	266.51	14.95	145.65
17	12.45	291.92	12.45	132.81
18	9.18	318.95	9.18	114.15
19	5.06	347.68	5.06	85.00
20	0.00	378.27	0.00	0.00

Implications of retrospective loss r.v.

- Realized retrospective loss r.v. represents historical claims experience
- A significant deviation of the realized retrospective loss r.v. from the retrospective reserves could indicate that prospective reserves should be adjusted
- Definition of significant deviation and level of adjustment of prospective reserves could use the GLM confidence approach discussed earlier
- A “credibility” adjustment could be created by having the confidence interval vary by reserve duration

➢ Later duration policies have tighter CI’s since more historical experience available

Credibility Adjusted Confidence Intervals

- Overall consistency requirement is that the later the policy duration, the tighter the confidence interval because of more credible historical experience
- Define the confidence interval width as 0.5*(upper CI – lower CI)

➢Keep the confidence width fixed for each duration which leads to tighter CI's as duration increases since the SD of the retrospective reserve increases by duration

➢Linearly decline the confidence width to zero from duration 1 to the end of the coverage period

- Any other reasonable method could be explored

Application: Assumptions

- Hypothetical in-force block of 20 year, fully discrete term insurance policies issued over the past 10 years.
- For each issue year, 100 policies are issued and they are randomly issued over issue ages 35 to 55 and face amounts $100,000 to $500,000
- Policy premiums are based on the Equivalence Principle
- For durations 1 to 5 (i.e. more recent issues), actual historical mortality is assumed to be 25% **lower** than reserving assumptions
- For durations 6 to 10 (i.e. earlier issues), actual historical mortality is assumed to be 25% **higher** than reserving assumptions

Application: Assumptions – cont'd

- Prospective reserves are adjusted based on deviations of the realized retrospective loss random variable from the confidence interval of the retrospective loss random variable. The confidence interval is based on 10% * SD for policies in duration 10 at the valuation date, 20% * SD for policies in duration 9, etc. and 1* SD for policies in duration 1 at the valuation date
- Assume the only decrement is mortality and the prospective reserve is being calculated at end of duration 10

Application: Adjustment to prospective reserves

Prospective Reserve Adjustment Example					
Issue Year	Realized Retro Loss RV Mean	Realized Retro Loss RV Deviation	Expected Prosp Loss RV Mean (Reserve)	Adjusted Prosp Loss RV Mean (Reserve)	Realized Prosp Loss RV Mean (Reserve)
1	13.30	-2.72	17.60	20.33	26.91
2	13.09	-0.60	16.60	17.20	26.04
3	13.00	Within Interval	15.86	15.86	25.68
4	11.07	Within Interval	13.10	13.10	22.10
5	11.31	Within Interval	13.05	13.05	23.05
6	12.44	Within Interval	11.20	11.20	1.12
7	7.94	Within Interval	7.26	7.26	-0.65
8	7.47	Within Interval	6.95	6.95	-2.54
9	4.55	Within Interval	4.32	4.32	-4.01
10	2.42	Within Interval	2.33	2.33	-6.13
Aggregate	9.66		10.80	11.11	11.04

Application: Adjustment to prospective reserves – cont'd

Remaining Policies	992.99
Remaining Policies Face Amount	297,226,683
Expected Retrospective Reserve	
Expected Prospective Reserve	10.80
Adjusted Prospective Reserve	11.11
Realized Prospective Reserve	11.04
Expected Aggregate Prospective Reserve	3,210,105
Adjusted Aggregate Prospective Reserve	3,303,576
Realized Aggregate Prospective Reserve	3,280,768
Per $1000 Difference Between Expected and Realized Prospective Reserves	-0.24
Per $1000 Difference Between Adjusted and Realized Prospective Reserves	0.08
Aggregate Difference Between Adjusted and Expected Prospective Reserves	93,471
Aggregate Difference Between Expected and Realized Prospective Reserves	(70,662)
Aggregate Difference Between Adjusted and Realized Prospective Reserves	22,808

Adjusting Prospective Reserves in Practice for an Inforce Block

- For a given inforce block of policies, a company should do the following at the valuation date

➢ Break up the inforce block by plan of insurance

➢ For a given plan of insurance, break up the policies by duration

➢ For a given duration, determine # of policies issued

➢ Calculate the *realized* retrospective reserve per 1000 at date of valuation

➢ Compare against the retrospective random variable CI for that duration and determine the *adjusted* prospective reserve per 1000

➢ Calculate the *total adjusted* prospective reserves for that duration

➢ Repeat the above for all durations and all plans of insurance

Conclusion and next steps

- Both the GLM and retrospective loss random variable approach represent a claims tracking and monitoring approach to adjusting actuarial assumptions
- The GLM approach may be more suited to adjusting pricing or plan assumptions while the retrospective loss rv approach is more appropriate for adjusting statutory reserves
- The retrospective loss rv is a new definition in the actuarial literature and a paper on this topic will be submitted for publication in the North American Actuarial Journal
- Both approaches are practical and implementable and can be expanded to any actuarial risk and any product design