CAS RPM Workshop
Basic Ratemaking
Ratemaking Relativities

Christopher Cooksey, FCAS, MAAA, CSPA
Head Actuary, Data & Analytics
Guidewire Software

19 March 2018

Agenda

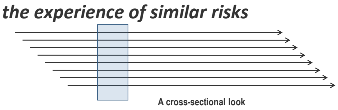
Introduction
Purpose of a Risk Classification
Considerations
Determining Rate Relativities
Implementing Changes
Questions

Determining Premiums

How might you determine a fair price for a given risk?

1. ***Wisdom and judgment***
2. ***Examine that risk's experience over time***

3. ***Examine the experience of similar risks***



Determining Premiums

The task of determining premiums for our customers is typically broken into two pieces –

Overall rate adequacy and Rate relativities

Finding the overall rate level separately allows for:

1. *Using all of your experience*
2. *Using overall trends and loss development*

Building relativity models to assign different rate levels allows for:

1. *Dealing with the multivariate nature of the problem*
2. *Ignoring trends and loss development (?!?)*

Introduction to Risk Classification

"The grouping of risks with similar risk characteristics for the purpose of setting prices is a fundamental precept of any workable private, voluntary insurance system.

This process, called risk classification, is necessary to maintain a financially sound and equitable system.

It enables the development of equitable insurance prices, which in turn assures the availability of needed coverage to the public.

This is achieved through the grouping of risks to determine averages and the application of these averages to individuals."

From the American Academy of Actuaries' Risk Classification Statement of Principles. Replaced in 2012 with the AAA Monograph On Risk Classification.

Introduction to Risk Classification

Three purposes of a risk classification system:

1. **Protect an insurer's financial soundness.**
2. **Enhance fairness.**
3. **Provide an insurer with economic incentive to write large portions of the market.**

Introduction to Risk Classification

Adverse selection occurs when economic forces are not in equilibrium – when buyers move in, out, and throughout the market.

Here is an example of adverse selection. ***The core driver in this example is an asymmetry of information.*** **Your competitor knows more about the customers than you do.**

Adverse Selection Example

This is the situation at time 0. The greyed rows show that these groups exist in your company, but you are unaware of them.

YOU	Current Exp	Price	Expected Prem	Expected Loss	Expected LR
Group A	10,000	$150	$1,500,000	$900,000	60.0%
Group B	10,000	$150	$1,500,000	$900,000	60.0%
Total	20,000	$150	$3,000,000	$1,800,000	60.0%

Competitor	Current Exp	Price	Expected Prem	Expected Loss	Expected LR
Group A	10,000	$100	$1,000,000	$600,000	60.0%
Group B	10,000	$200	$2,000,000	$1,200,000	60.0%
Total	20,000	$150	$3,000,000	$1,800,000	60.0%

Adverse Selection Example

Even with ¼ of customers shopping, you aren't aware of the mix shift. You just know you didn't hit your target loss ratio.

YOU	Actual Exp	Ave Prem	Actual Prem	Actual Loss	Actual LR
Group A	7,500	$150	$1,125,000	$450,000	40.0%
Group B	12,500	$150	$1,875,000	$1,500,000	80.0%
Total	20,000	$150	$3,000,000	$1,950,000	65.0%

Competitor	Actual Exp	Ave Prem	Actual Prem	Actual Loss	Actual LR
Group A	12,500	$100	$1,250,000	$750,000	60.0%
Group B	7,500	$200	$1,500,000	$900,000	60.0%
Total	20,000	$138	$2,750,000	$1,650,000	60.0%

Adverse Selection Example

The higher loss ratio gives you an 8.3% indicated rate need. So you adjust your prices up accordingly.

YOU	Current Exp	Price	Expected Prem	Expected Loss	Expected LR
Group A	7,500	$163	$1,218,750	$731,250	60.0%
Group B	12,500	$163	$2,031,250	$1,218,750	60.0%
Total	20,000	$163	$3,250,000	$1,950,000	**60.0%**

Competitor	Current Exp	Price	Expected Prem	Expected Loss	Expected LR
Group A	12,500	$100	$1,250,000	$750,000	60.0%
Group B	7,500	$200	$1,500,000	$900,000	60.0%
Total	20,000	$138	$2,750,000	$1,650,000	60.0%

Adverse Selection Example

Rate changes don't fix the problem because average rate level isn't the issue.

YOU	Actual Exp	Ave Prem	Actual Prem	Actual Loss	Actual LR
Group A	5,625	$163	$914,063	$337,500	36.9%
Group B	14,375	$163	$2,335,938	$1,725,000	73.8%
Total	20,000	$163	$3,250,000	$2,062,500	**63.5%**

Competitor	Actual Exp	Ave Prem	Actual Prem	Actual Loss	Actual LR
Group A	14,375	$100	$1,437,500	$862,500	60.0%
Group B	5,625	$200	$1,125,000	$675,000	60.0%
Total	20,000	$128	$2,562,500	$1,537,500	60.0%

Adverse Selection Example

The example shows us several things:

- **Your primary defense against adverse selection is risk classification.**

  Purpose 1: Protect an insurer's financial soundness.

- **Because they were properly priced, your competitor was happy to write the entire market.**

  Purpose 3: Provide an incentive to write large portions of the market.

- **Because each group's price matched their risk level, your competitor's prices are more equitable.**

  Purpose 2: Enhance fairness.

Risk Classification Considerations

How a risk classification system is designed will affect its ability to achieve its purpose. The reading highlighted many issues, among them…

- **Underwriting and marketing**
- **Program design**
- **Statistical and operational considerations**
- **Public acceptability**
- **Causality**
- **Controllability**
- **Etc.**

Risk Classification Considerations

What are the issues around using this information as part of your risk classification system?

- **Living in a flood plain and property insurance**
- **Policy limits**
- **Credit reports and personal lines insurance**
- **Accident avoidance technology and auto insurance**
- **Telematics and auto insurance (including commercial auto)**
- **Autonomous vehicles and auto insurance, commercial insurance, workers compensation, product liability, etc.**

Determining Rate Relativities

Premiums that vary by customer are achieved through a common base rate (which reflects the overall rate adequacy) and a series of relativities that push this rate up or down.

Two basic approaches:

- **Loss cost, or pure premium – model loss cost (or frequency/severity) to determine relative costs per unit exposure. This is a ground-up approach.**
- **Loss ratio – model existing loss ratios to determine changes to existing relativities.**

Univariate Loss Cost

In a univariate approach, each rating field is examined *individually*, without respect to other rating fields.

Younger drivers' loss cost are 3.20 times as high as older drivers, and pointed drivers' loss cost are 1.69 times as high as clean drivers.

With no other information, we assume younger, pointed drivers would be 5.42 times as high as older, clean drivers.

3.20 x 1.69 = 5.42

Age	Exposure	Loss	Loss Cost	Relativity
Younger	150	6,000	40.0	3.20
Older	1000	12,500	12.5	1.00
Total	1,150	18,500	16.1	

Points	Exposure	Loss	Loss Cost	Relativity
Clean	550	6,500	11.8	1.00
Pointed	600	12,000	20.0	1.69
Total	1,150	18,500	16.1	

Multivariate Loss Cost

The problem with the univariate approach is that we are *double-counting* the risk. Being younger indicates higher risk, and having points indicates higher risk, but being younger correlates with having points, so there is overlap.

Once moving to a multivariate approach, we can see from the tables this correlation:

Half of adults have points, but 2/3 of younger drivers have points.

Being younger make you more likely to have points.

Age	Points	Exposure	Loss	Loss Cost	Relativity
Younger	Clean	50	1,500	30.0	3.00
Younger	Pointed	100	4,500	45.0	4.50
Older	Clean	500	5,000	10.0	1.00
Older	Pointed	500	7,500	15.0	1.50
Total		1,150	18,500	16.1	

Univariate Loss Ratio

Univariate loss ratios translate to rate relativities slightly differently.

First, understand that premium should be brought to current rate levels.

Second, finding the loss ratio relativity is straight-forward, but this is NOT the rate relativity. Consider – which class is higher risk?

Class	Premium @CRL	Losses	Loss Ratio	Loss Ratio Relativity		
1	$1,168,125	$759,281	0.65	1.00		
2	$2,831,500	$1,472,719	0.52	0.80		

Univariate Loss Ratio

Univariate loss ratios translate to rate relativities slightly differently.

First, understand that premium should be brought to current rate levels.

Second, finding the loss ratio relativity is straight-forward, but this is NOT the rate relativity. Consider – which class is higher risk?

The loss ratio relativity indicates the *change* in the rate relativity.

Class	Premium @CRL	Losses	Loss Ratio	Loss Ratio Relativity	Current Rate Relativity	Proposed Rate Relativity
1	$1,168,125	$759,281	0.65	1.00	1.00	1.00
2	$2,831,500	$1,472,719	0.52	0.80	2.00	1.60

Univariate Loss Ratio

Univariate loss ratios are more useful than univariate loss costs because the premium in the ratio implicitly contains information about the rest of the rating plan. The average premiums reflect the effect of other rating fields.

Age	Exposure	Premium	Loss	Loss Cost	Loss Ratio	Ave Prem
Younger	150	8,250	6,000	40.0	72.7%	55.0
Older	1000	23,000	12,500	12.5	54.3%	23.0
Total	1,150	18,500	18,500			

Age	Exposure	Premium	Loss	LC Rel	LR Rel	AP Rel
Younger	150	8,250	6,000	3.20	1.34	2.39
Older	1000	23,000	12,500	1.00	1.00	1.00
Total	1,150	18,500	18,500			

3.20 = 1.34 * 2.39

Univariate Loss Ratio

While useful, we can't use univariate loss ratios exclusively.

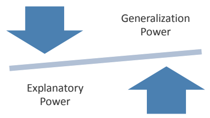
Loss ratios assume that the rest of the rating plan is correct. This is a bad assumption if many rate relativities need to be adjusted. This is an absurd assumption if evaluating an entire rating plan.

There is also no approach for quantifying the variability in our estimates (true for loss cost too, so far). What we really need is a more robust approach.

Determining Rate Relativities

Insurance is inherently random. Any set of data we have includes both a systematic and random component. Because of this noise, we can't fully believe any loss cost or loss ratio we have.

Yet there is information in our data. All modeling is therefore a balancing act. We want to extract only the information from our data that will generalize to new data.



Determining Rate Relativities

Multivariate loss cost approaches include…

- **Multi-way tables – can incorporate credibility, but limits on size and no estimate of noise.**
- **Minimum Bias – easy to implement (Excel!), but no estimate of noise.**
- **Generalized Linear Models – statistically-based regression with error structures appropriate to insurance.**
- **Other approaches – GLMM, GAMs, Penalized Regression, etc.**

Determining Rate Relativities

One drawback of loss cost approaches is that they are a ground-up determination of rate relativities with no tie to existing relativities. This can lead to significant rate swings and large implementation issues.

Multivariate loss ratio approaches have the potential to find adjustments to current premiums that are easier to implement.

Machine learning techniques, including GBM, Random Forest, and other ensemble approaches, are useful for exploring patterns in loss ratio.

Implementing changes

All relativity changes have the potential to impact the premium collected, and therefore the overall rate level.

Rate Impact – the change in the overall rate level that relativity changes would have in and of themselves.

Off-balance – the adjustment to base rates that would off-set the rate impact such that the combined change is revenue neutral. The off-balance is therefore the inverse of the rate impact.

Implementing changes

There are at least three ways to estimate the rate impact.

1. Exposure-weighted average rate impact – simplest, but least accurate. Use this when a premium-weighted or rerating approach is not available.
2. Premium-weighted average rate impact – most accurate when a rerating approach is not available. Becomes more problematic the more changes are considered.
3. Rerated rate impact – conceptually the most straight-forward approach, accurate even for many changes. Is the most costly with respect to preparation and computing power.

Implementing changes

Consider a simple case. Fire Hydrant Distance is an existing rating variable. The base is having one nearby (0-3 miles), with a 20% surcharge for being far away (3+ miles). Your analysis says you should increase this to a 40% surcharge.

If nothing else changes, then increasing this surcharge on a portion of the book means that the same customers will generate more premium. This would count as a rate change if we don't off-balance it.

Implementing changes

Exposure-weighted average rate impact

Just like it sounds. Find the exposure-weighted average relativities and see how they change.

The average relativity increases 7.4%. *Assuming the average premium is the same for both levels of FHD*, the premium will increase the same. Reducing base rates 6.9% will off-set this.

FHD	Exposures	Current Rel	Proposed Rel
0-3	12,000	1.00	1.00
3+	8,000	1.20	1.40
Total	20,000	1.08	1.16
		Rate Impact	7.4%
		= (1.16 / 1.08) – 1	
		Off-balance	-6.9%
		= 1 / (1 + 0.074) - 1	

Implementing changes

Premium-weighted average rate impact

Find the premium-weighted average relativities and see how they change. The premium to use is the base premium as defined here. This presentation is more intuitive.

FHD	Exposures	Current Premium	Current Relativity	Base Premium	Proposed Relativity	Proposed Premium
0-3	12,000	14,142,000	1.00	14,142,000	1.00	14,142,000
3+	8,000	8,061,000	1.20	6,717,500	1.40	9,404,500
Total	20,000	22,203,000		20,859,500		23,546,500
					Rate Impact	6.1%
					= (23,546,500 / 22,203,000) – 1	
					Off-balance	-5.7%
					= 1 / (1 + 0.061) – 1	

Again, this becomes more distorted the more changing relativities there are.

Implementing changes

Rerated rate impact

Rerating, also called Extension of Exposures, is the process of taking a book of business and calculating the premiums using a specified rating algorithm.

In this approach, we simply rate the book of business as if they are using all of the proposed rates. If the new rates produce a total premium of $24,667,000, then we know the rate impact is 11.1%...

$24,667,000 / $22,203,000 -1 = 11.1%

In Summary…

- Risk classifications are necessary to guard against adverse selection, promote fairness by avoiding subsidies, and encourage a wide coverage of insurance.
- Many practical considerations go into risk classification.
- GLMs (and other techniques) are typically used to determine rate relativities through a loss cost (or freq/sev) analysis.
- Loss ratios can also be used to modify existing premiums.
- Rate impacts and off-balances are used to ensure that changes are revenue neutral.

CAS RPM Workshop: Basic Ratemaking
Ratemaking Relativities

QUESTIONS?

Contact Info
Chris Cooksey, FCAS, MAAA, CSPA
Head Actuary, Data & Analytics
Guidewire Software
ccooksey@guidewire.com
740-398-2629