OHIO STATE UNIVERSITY – MATH 588–ACTUARIAL PRACTICUM
INTRODUCTION TO PROPERTY AND CASUALTY INSURANCE

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INTRODUCTION TO PROPERTY AND CASUALTY INSURANCE
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Exposure - basic rating unit underlying an insurance premium

Written Car Year - exposure unit representing one year of insurance coverage for one automobile on policies written during the year

Earned Car Yr(E)- exposure unit representing one year of insurance coverage for one automobile on policies exposed to loss during the year

Claim - demand for payment by an insured or by an allegedly injured third party

under the terms and conditions of an insurance contract resulting in potential liability to the insurance company

Claimant - individual making the claim

Accident Date - date of the occurrence giving rise to the claim

Report Date - date the insurer receives notice of the claim

Evaluation Date - date through which the claim transactions are included

Accident Year - refers to accumulation of all claims with accident dates during the year
Accident Year Incurred Claim Count (C) -the number claims occurring in a certain period

Accident Year Incurred Losses (L) -the amount of paid amounts and unpaid case reserves for a specific accident year as of a specific evaluation date

Frequency (F) - a measurement of the incidence of claims per exposure

(Eqn. 1) $$\text{Accident Year Incurred Claim Frequency} = \frac{\text{Accident Year Incurred Claim Count}}{\text{Earned Car Years}}$$

$$F = \frac{C}{E}$$

(Eg: If there are 100 cars insured for a year & 10 accidents during the year then Freq.=0.10)

Severity (S) - a measurement of the size of claims or average loss per claim

(Eqn. 2) $$\text{Accident Year Incurred Claim Severity} = \frac{\text{Accident Year Incurred Losses}}{\text{Accident Year Incurred Claim Count}}$$

$$S = \frac{L}{C}$$

(Eg: If there are 10 accidents giving rise to 10 AutoCollision claims during the year and the paid claim amounts (after applying deductible) are $8000, $2500, $250, $12000, $750, $1500, $1000, $500,$3000, and $500 then Total Incurred Losses = $30,000 and Severity = $30000/10=$3000)

Pure Premium (P) - a measurement of the average loss per exposure

(Eqn. 3) $$\text{Accident Year Incurred Pure Premium} = \frac{\text{Accident Year Incurred Losses}}{\text{Earned Car Years}}$$

$$= \left(\frac{\text{Accident Year Incurred Claim Count}}{\text{Earned Car Years}}\right) \times \left(\frac{\text{Accident Year Incurred Losses}}{\text{Accident Year Incurred Claim Count}}\right)$$

$$= (\text{Incurred Claim Frequency}) \quad \times \quad (\text{Incurred Claim Severity})$$

$$P = \frac{L}{E} = \left(\frac{C}{E}\right) \times \left(\frac{L}{C}\right) = (F) \times (S)$$

(Eg: If there are 10 accidents giving rise to 10 AutoCollision claims during the year and the paid claim amounts (after applying deductible) are $8000, $2500, $250, $12000, $750, $1500, $1000, $500,$3000, and $500 then Total Incurred Losses = $30,000 and Severity = $30000/10=$3000.
Then the Pure Premium = ($3000)x(0.10)=$300=($30000 Losses/100 Car Years)

Rate Per Exposure - the insurance premium necessary to adequately cover the expected incurred losses and expense costs of providing insurance coverage

(Eqn. 4)

$$Indicated\ Rate\ Per\ Car\ Year = \frac{Pure\ Premium + Fixed\ Expense\ Per\ Exposure}{1 - Variable\ Expense\ Factor - Profit\ and\ Contingencies\ Factor}$$

$$R = \frac{P + F}{1 - V - Q}$$

(Eg: If the Fixed Expenses are currently \$50 per vehicle, Variable Expenses are 25% of premium and Profit and Contingencies are 5% of premium then the rate provision before variable expenses and profit would be \$300+\$50=\$350. This \$350 would then be grossed up for the variable expense and profit loadings (as a 30% of premium). Then the total Indicated Rate would be \$350/0.70 = \$500)

Pure Premium Ratemaking -exposure based method which develops indicated **rates**
Loss Ratio Ratemaking -premium based method which develops indicated **rate changes**

TWO RATEMAKING METHODS

Pure Premium Method	Loss Ratio Method
Based on exposures (eg. Car Years)	Based on earned premiums
Do not require existing rates	Requires existing rates (R_0)
Do not use on level premium	Uses on level premiums to derive average R_0
Produces indicated rates	Produces indicated rate changes

Loss Ratio - a ratio of incurred losses to earned premiums

Experience Loss Ratio -the actual loss ratio based on the loss experience
(Eqn. 5)

$$Experience\ Loss\ Ratio = \frac{Accident\ Year\ Incurred\ Losses}{Earned\ Premiums} = \frac{Accident\ Year\ Incurred\ Losses}{Earned\ Car\ Years \times Current\ Rate\ Per\ Car\ Year}$$

$$W = \frac{L}{E \times R_0}$$

(Eg: If the Current Rate is only \$400, there are 100 cars insured for a year, then the earned premiums would be \$400/car x 100 cars = \$40000. Since the incurred losses total \$30000, the Experience Loss Ratio = \$30000 losses/\$40000 premium = 0.75=75%)

Target Loss Ratio -the maximum loss ratio allowable to allow a reasonable provision for profit and contingencies left over after expenses and incurred losses are paid

(Eqn. 6)

$$Target\ Loss\ Ratio = \frac{1 - Variable\ Expense\ Provision - Profit\ and\ Contingencies\ Factor}{1 + Ratio\ of\ Fixed\ (Non-Premium\ Related)\ Expenses\ to\ Incurred\ Losses}$$

$$T = \frac{1 - V - Q}{1 + G}, \qquad \text{where (Eqn. 7)} \quad G = \frac{E \times F}{L} = \frac{F}{\left(\frac{L}{E}\right)} = \frac{F}{P}$$

(Eg: If the Fixed Expenses are currently \$50 per vehicle, Variable Expenses are 25% of premium and Profit and Contingencies are 5% of premium then the numerator = 1-0.30=0.70. G=\$50 fixed expense per car/\$300 pure premium per car= .166 so the denominator = 1.16666. Then the Target Loss Ratio = 0.70/1.16666=0.60=60%)

Indicated Rate Change - the change in insurance premiums necessary to adequately cover the expected incurred losses and expense costs of providing insurance coverage

(Eqn. 8)

$$Indicated\ Rate\ Change = \frac{Experience\ Loss\ Ratio}{Target\ Loss\ Ratio}$$

$$I = \frac{W}{T}$$

(Eg: If the Experience Loss Ratio of 75% is higher than the Target Loss Ratio of 60% then an indicated rate change of .75/.60=125% of the current rates is needed. This would mean that current rates need increased by 25%.)

(Eqn. 9)

$$Indicated\ Rate\ Per\ Car\ Year = Indicated\ Rate\ Change \times Current\ Rate\ Per\ Car\ Year$$

$$R = I \times R_0$$

(Eg: If 125% of the current rates is needed and current rates are \$400 per car year, then the indicated rate is 125% x \$400/car = \$500/car. This Loss Ratio calculation is the same answer derived by the Pure Premium method)

TAKE HOME PROBLEMS

1. Prove that the Pure Premium and Loss Ratio ratemaking methods are mathematically equivalent (ie. Start with Eqn. 9 and derive Eqn. 4 using Eqn. 7 and the definitions of W, T, and P)
2. Given the following data:

PROBLEM 2 DATA

Data	Variable	Adult Drivers	Youthful Drivers	All Drivers Combined
Number of Cars Insured for One Year	E	90	10	100
Claim 1	C,L	$8,000	-	$8,000
Claim 2	C,L	$2,500	-	$2,500
Claim 3	C,L	$250	-	$250
Claim 4	C,L	-	$12,000	$12,000
Claim 5	C,L	-	$750	$750
Claim 6	C,L	-	$1,500	$1,500
Claim 7	C,L	$1,000	-	$1,000
Claim 8	C,L	$500	-	$500
Claim 9	C,L	$3,000	-	$3,000
Claim 10	C,L	$500	-	$500
Fixed Expense Per Vehicle	F	$50/car	$50/car	$50/car
Variable Expenses	V	25%	25%	25%
Profit and Contingencies	Q	5%	5%	5%

(a) What should the overall rate be for all drivers, for youthful drivers, and for adult drivers?
(b) Are youthful drivers in accidents more frequently than adults?
(c) Are adult drivers accidents more severe (as measured by size of claim) than youthfuls?
(d) Given the answers developed in 2(b) and 2(c), which types of drivers would be more difficult to determine a price for?
(e) Why would it be more difficult to price for these types of drivers?
(f) The state Department of Insurance is scrutinizing rates your company filed and is comparing the ratio of (Youthful to Adult) final total rates. The DOI holds up approving your rate filing pending some questions. Their question is why is the ratio of Youthful to Adult Total Rates **different** than the ratio of Youthful to Adult Pure Premiums? They contend: "Shouldn't drivers be charged based only on the difference in their loss experience? So for example, if experience of Class A is X times worse Class B, why wouldn't the final rate for Class A be exactly X times more than Class B?" Explain this.
(g) Since the ratio of Rates is **different** than the ratio of Pure Premiums, one class (Youthful or Adults) is benefitting compared to their Pure Premiums. Which class is benefiting?

3. Given the following data:

PROBLEM 3 DATA

Data	Claim	Dwelling	Contents	All

	Peril/ Coverage	Coverage	Coverage	Coverages Combined
Number of Homes Insured for One Year		1,000	900	1,000
Claim 1	Fire	$80,000	$50,000	$130,000
Claim 2	Theft	$500	$2,500	$3,000
Claim 3	Wind/Hail	$4,000	-	$4,000
Claim 4	Wind/Hail	$2,800	-	$2,800
Claim 5	Wind/Hail	$3,200	-	$3,200
Claim 6	Wind/Hail	$8,900	-	$8,900
Claim 7	Water	$1,000	$3,000	$4,000
Claim 8	Freezing	$500	-	$500
Claim 9	Liability	$30,000	-	$30,000
Claim 10	Fire	$500	-	$500
Fixed Expense Per House		$50/house	$50/house	$50/house
Variable Expenses		25%	25%	25%
Profit and Contingencies		5%	5%	5%

(a) What should the overall rate be for all perils/coverages for both Dwelling and Contents Coverage?

(b) Which of the 6 different Homeowners Perils/Coverages are most likely to occur (across both Dwelling & Contents)?

(c) Which of the 6 different Homeowners Perils/Coverages are least likely to occur (across both Dwelling & Contents)?

(d) What is the Pure Premium (across both Dwelling & Contents) for each of the 6 different perils?

(e) Which Peril/Coverage has the highest severity (across both Dwelling & Contents)?

(f) Which Peril/Coverage has the lowest severity (across both Dwelling & Contents)?

(g) Which Peril/Coverage would be the most difficult to price – based on volatility of claims, variance, and/or credibility (across both Dwelling & Contents)?

(h) This state has been plagued by repeated Hailstorms in the past 5 years that have led to inadequacy on that portion of the premium. What options (other than simply increasing the rate) could the company take to ensure they do not continue to lose money , yet remain competitive price wise?

4. Property & Casualty actuaries often use quarterly and four quarter ending historical data from the past 3-5 years to predict what will happen in the future. More specifically, average frequency, average severity, and average pure premium data in each quarter are analyzed and a regression performed to project changes in these metrics expected to occur in the future. Which type of regression (linear or exponential) is typically preferred for this projection? Why?
5. Recent data (last 2 years) shows frequency increasing/spiking upwards dramatically along with decreasing severity, which seems unlikely given long term inflationary historical patterns. Do you believe the more recent frequency & severity trend data or ignore it? What is your reasoning behind your decision, and what factors might you consider?

6. You are the actuary for YUR Consulting Firm investigating a questionable insurance rate charged by XYZ insurance company. XYZ has agreed to insure ABC for the television game show "Who Wants to Be a Millionaire?" for the cash prizes that contestants can potentially win. XYZ currently charges the game show a premium of $223.09 per show.

   XYZ based its premium on the experience of a similar British game show. In that show, the questions are so difficult that no one knows any of the answers and the probability of getting a question correct is simply the random probability of getting a multiple choice question correct out of four choices (ie. Probability correct = ¼)

   After a few months, XYZ complains that ABC has made the questions on the game show too easy and sues ABC, charging that ABC misrepresented how the game show would be designed and this resulted in inadequate estimates of premium. XYZ hires YUR to determine what the insurance premium should be for presentation in the upcoming court case. Using the information below, determine what the premium per show should be.

PROBLEM 6 DATA

Data	Variable	
Number of Contestants Per Game Show	E	2
Uniform Probability of Getting a Question Correct*	C	½
Prize After 1st Question Correct	C,L	$100
Prize After 2 Questions consecutively correct	C,L	$250
Prize After 3 Questions consecutively correct	C,L	$500
Prize After 4 Questions consecutively correct	C,L	$1,000
Prize After 5 Questions consecutively correct	C,L	$2,000
Prize After 6 Questions consecutively correct	C,L	$5,000
Prize After 7 Questions consecutively correct	C,L	$7,000
Prize After 8 Questions consecutively correct	C,L	$10,00
Prize After 9 Questions consecutively correct	C,L	$15,000
Prize After 10 Questions consecutively correct	C,L	$20,000
Prize After 11 Questions consecutively correct	C,L	$25,000
Prize After 12 Questions consecutively correct	C,L	$50,000
Prize After 13 Questions consecutively correct	C,L	$100,000
Prize After 14 Questions consecutively correct	C,L	$250,000
Prize After 15 Questions consecutively correct	C,L	$500,000
Prize After 16 Questions consecutively correct	C,L	$1,000,000
Fixed Expense Per Contestant	F	$100/contestant
Variable Expenses	V	25%
Profit and Contingencies	Q	5%

*You have determined that every question is made so easy that two of the four choices are obviously wrong to each contestant (therefore making it a guess between two answers)

Assume that the contestants do not lose their cumulative winnings from previous questions when they answer a subsequent question wrong. (so the only ones receiving no prize are the ½ who answer the first question wrong)

Also assume that contestants win the full prize amount listed for each question answered correctly and can accumulate prize money (so someone answering all 16 questions actually receives the sum of all prizes which is more than 1 million dollars.)

Also assume all questions are independent and identically distributed (ie. Probabilities remain constant at ½)

Each of the various prizes that can be awarded have varying frequencies based on the probabilities of occurring
(ie. P[$5,000 prize for one contestant]=(1/2)*(1/2)*(1/2)*(1/2)*(1/2)*(1/2)=(1/2)^^{6}

The Total Incurred Losses can be estimated as the sum of each of the prize awards x the probability of a contestant winning each of those awards. (ie. Use the expected value function E[L].)

7. BONUS / CHALLENGE QUESTION (OPTIONAL)…
The marketing director for your television network says that "Who Wants to Be a Millionaire?" is soooo last century and your network needs a better show. You are the actuary for YUR Consulting Firm trying to determine the formula the banker should use to calculate the deal offered for each iteration a new game show she is marketing called "Deal or No Deal". This show involves a contestant first selecting 1 of 25 suitcases, one of which contains $1 million. Then they must choose whether to open various suitcases or make a "deal" with the game show to surrender their suitcase in return for the expected value of the prize amount in their suitcase, based on the conditional probability given knowledge about all other suitcases that have already been opened. Assume that only the expected winnings in the suitcase that the contestant holds need to be included in the estimate and no additional monies are needed for profit, risk loads in case the prize amount is large, etc..