Math 417C Loss Models III Spring 2014
9:00 – 9:50 (Bouillon 101 M&W, Bouillon 103 F)

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Prerequisite: Math 417B or by permission.

Text:
1. Required: Stuart A. Klugman, Harry H. Panjer, Gordon E. Willmot, Loss Models, Wiley 2012.
2. Recommended: Samuel A. Broverman, Actex C/4 Study Manual

The students will be introduced to useful frequency and severity models. They will be required to understand the steps involved in the modeling process and how to carry out these steps in solving business problems. The students should be able to:
(i) analyze data from an application in a business context;
(ii) determine a suitable model including parameter values; and
(iii) provide measures of confidence for decisions based upon the model.
The students will be introduced to a variety of tools for the calibration and evaluation of the models.

Learning outcomes:
After taking this sequence, the students are expected to be familiar with survival, severity, frequency and aggregate probability models, and use statistical methods to estimate parameters of such models given sample data. The students are further expected to identify steps in the modeling process, understand the underlying assumptions implicit in each family of models, recognize which assumptions are applicable in a given business application, and appropriately adjust the models for impact of insurance coverage modifications.

LEARNING OUTCOMES for SOA Exam C (Construction and Evaluation of Actuarial Models)
The candidate is expected to be familiar with survival, severity, frequency and aggregate models, and use statistical methods to estimate parameters of such models given sample data. The candidate is further expected to identify steps in the modeling process, understand the underlying assumptions implicit in each family of models, recognize which assumptions are applicable in a given business application, and appropriately adjust the models for impact of insurance coverage modifications.
Specifically, the candidate is expected to be able to perform the tasks listed below. Items in italic font are additions or replacements with respect to the June 2013 syllabus.
Sections A–E have a combined weight of 15-20%.
A. Severity Models
1. Calculate the basic distributional quantities:
   a) moments
   b) Percentiles
   c) Generating functions
2. Describe how changes in parameters affect the distribution.
3. Recognize classes of distributions and their relationships.
4. Apply the following techniques for creating new families of distributions:
   a) Multiplication by a constant
   b) Raising to a power
   c) Exponentiation,
   d) Mixing
5. Identify the applications in which each distribution is used and reasons why.
6. Apply the distribution to an application, given the parameters.

7. Calculate various measures of tail weight and interpret the results to compare the tail weights.
8. *Identify and describe two extreme value distributions.*

B. Frequency Models

For the Poisson, Mixed Poisson, Binomial, Negative Binomial, Geometric distribution and mixtures thereof:

1. Describe how changes in parameters affect the distribution,
2. Calculate moments,
3. Identify the applications, for which each distribution is used and reasons why,
4. Apply the distribution to an application given the parameters.
5. Apply the zero-truncated or zero-modified distribution to an application given the parameters

C. Aggregate Models

1. Compute relevant parameters and statistics for collective risk models.
2. Evaluate compound models for aggregate claims.
3. Compute aggregate claims distributions.

D. For severity, frequency and aggregate models

1. Evaluate the impacts of coverage modifications:
   a) Deductibles
   b) Limits
   c) Coinsurance
2. Calculate Loss Elimination Ratios.
3. Evaluate effects of inflation on losses.

E. Risk Measures

1. Calculate VaR, and TVaR and explain their use and limitations.

Sections F and G have a combined weight of 20-25%.

F. Construction of Empirical Models

1. Estimate failure time and loss distributions using:
   a) Kaplan-Meier estimator
   b) Nelson-Åalen estimator
   c) Kernel density estimators
2. Estimate the variance of estimators and confidence intervals for failure time and loss distributions.
3. Apply the following concepts in estimating failure time and loss distribution:
   a) Unbiasedness
   b) Consistency
   c) Mean squared error

G. *Estimation of decrement probabilities from large samples*

1. *Estimate decrement probabilities using both parametric and nonparametric approaches for both individual and interval data*
2. *Approximate the variance of the estimators*

H. Construction and Selection of Parametric Models (25-30%)

1. Estimate the parameters of failure time and loss distributions using:
   a) Maximum likelihood
   b) Method of moments
   c) Percentile matching
   d) Bayesian procedures
2. Estimate the parameters of failure time and loss distributions with censored and/or truncated data using maximum likelihood.
3. Estimate the variance of estimators and the confidence intervals for the parameters and functions of parameters of failure time and loss distributions.
4. Apply the following concepts in estimating failure time and loss distributions:
   a) Unbiasedness
   b) Asymptotic unbiasedness
   c) Consistency
   d) Mean squared error
   e) Uniform minimum variance estimator
5. Determine the acceptability of a fitted model and/or compare models using:

a) Graphical procedures
b) Kolmogorov-Smirnov test
c) Anderson-Darling test
d) Chi-square goodness-of-fit test
e) Likelihood ratio test
f) Schwarz Bayesian Criterion

I. Credibility (20-25%)

1. Apply limited fluctuation (classical) credibility including criteria for both full and partial credibility.
2. Perform Bayesian analysis using both discrete and continuous models.
3. Apply Bühlmann and Bühlmann-Straub models and understand the relationship of these to the Bayesian model.
4. Apply conjugate priors in Bayesian analysis and in particular the Poisson-gamma model.
5. Apply empirical Bayesian methods in the nonparametric and semiparametric cases.

J. Simulation (5-10%)

1. Simulate both discrete and continuous random variables using the inversion method.
2. *Simulate from discrete mixtures, decrement tables, the (a,b,0) class, and the normal and lognormal distributions using methods designed for those distributions*
3. Estimate the number of simulations needed to obtain an estimate with a given error and a given degree of confidence.
4. Use simulation to determine the p-value for a hypothesis test.
5. Use the bootstrap method to estimate the mean squared error of an estimator.
6. Apply simulation methods within the context of actuarial models.

Course outlines:

	Topic	Days (one day is one-hour)
I	Aggregate loss models (Chapter 9 Revisit 9.7, 9.8) 1. Aggregate claims 2. Compound models 3. The individual risk model 4. Compound Poisson approximation	3
II	Model Selection (Chapter 16) 1. Representations of the data and model 2. Graphical comparison of the density and distribution functions 3. Hypothesis tests: K-S test, Anderson-Darling test, Chi-square Goodness-of-fit test, Likelihood ratio test 4. Selecting a model: Judgment-based and score-based	7
III	Empirical Bayes parameter estimation (Chapter 18, 19)	7
IV	Data Modeling Project (Friday lab for class or SOURCE project) *Check out Canvas weekly for assignment update! We basically Implement the theories to Excel workbook as far as we can. The Excel workbook will be the class project that can be presented at the SOURCE by adding a brief data application.*	10
	TESTING (Test date will be announced at least a week ahead)	3
	TOTAL	30

Class format: Mixture of lectures, in-class problem solving, and computer lab. Students present their solutions of the assigned problems and answer questions raised by the instructor and other students. Group discussions to explain concepts and work on MS Excel simulation and modeling projects.

Grading policy:

1. Project and participation (150 points)
2. Assignments (150 points)
3. Three Quizzes (150 points)
4. Final exam (100 points)

Final grades will be assigned according to the following scale:

A 100-93% **A-** 92.9-90%
B+ 89.9-87% **B** 86.9-83% **B-** 82.9-80%
C+ 79.9-77% **C** 76.9-73% **C-** 72.9-70%
D+ 69.9-67% **D** 66.9-63% **D-** 62.9-60%
F 59.9% and below

Class Expectations

- ***Think critically***. This course will require critical thinking. People that analyze, infer, evaluate, and make reasoned judgments do better in college and career, make better daily decisions, and have greater professional success. Developing critical thinking and reasoning should be a key goal of every student.

- ***Apply yourself.*** This course will take a lot of time and energy. You should have high learning expectations and challenge yourself. Success in this course will require significant effort (several hours of study time for each hour of class). Depending on your mathematical background, you may need to spend more or less study time. Attend class regularly, be on time, and budget your time to accommodate the workload.

- ***Ask questions***. Loss Modeling is fascinating, but it can be confusing sometimes, too. Ask questions. If you aren't clear on something, there are likely others who are equally unclear on the specific detail or area. Asking questions help your peers and the instructor deliver/facilitate effective lessons.

- ***Be informed***. People sometimes use information to manipulate others' behaviors and decision-making in ways not always to your benefit. If you don't understand the mathematical basis of a claim about data, you can't make an informed decision about it. Be curious; try and find out all you can about a topic before you make a decision that may profoundly affect your life and career.

- ***Communicate clearly***. Effective written and oral communication of difficult concepts and techniques indicates an intelligent mind and true understanding. Clarity, proper format, spelling, and grammar are expected of every student.

- ***Use common sense***. Cheating on assignments or exams, plagiarizing others' work, and turning in late assignments is unacceptable. Any infractions may result in a zero for the assignment, a failing course grade, and the possibility of disciplinary action by the university. I won't accept *anything* late unless you have written documentation from an appropriate source or have made prior arrangements with me. If you have a problem that prohibits you from turning something in on time, let me know ahead of time. In all instances, communicate with me so we can prevent future problems.

SOURCE Project. SOURCE is not required to have class credits but highly encouraged. Projects without public presentation may not be as great marketing for the resume as the similar ones presented at SOURCE. Participating in SOURCE symposium is highly advised by our actuarial graduates and recruiters. We had actuarial majors participating

SOURCE since 2001 and it has become a program tradition. Our students often won the best presentation prizes in their categories/sessions!

Students in Math 410B and Math 417C concurrently can do an optional joint SOURCE project combining statistics and probability modeling to satisfy course requirements had a senior student incredibly did it (Math 419C and 410B) and her work was featured in an article of SOA newsletter. The class projects are the learning priority and can/should be used to form/aid your SOURCE project by deciding a worthy title, its abstract to articulate the application(s) in mind. Using real-world data and then modeling their probability distributions for analysis is a more efficient way to start.

Class projects are required for course credits for both Math 410B and Math 417C regardless whether or not students will participate in SOURCE.

For the project that is going to enter SOURCE, I need the abstract in a week before the due date so that I have enough time to help it get accepted.