UCSB Probability & Statistics Actuarial Program

Presentation by

Roger M. Hayne, Ph.D., FCAS, MAAA

CAS Annual Meeting
Orlando, FL
14 November 2016

Unique Actuarial Program at UCSB

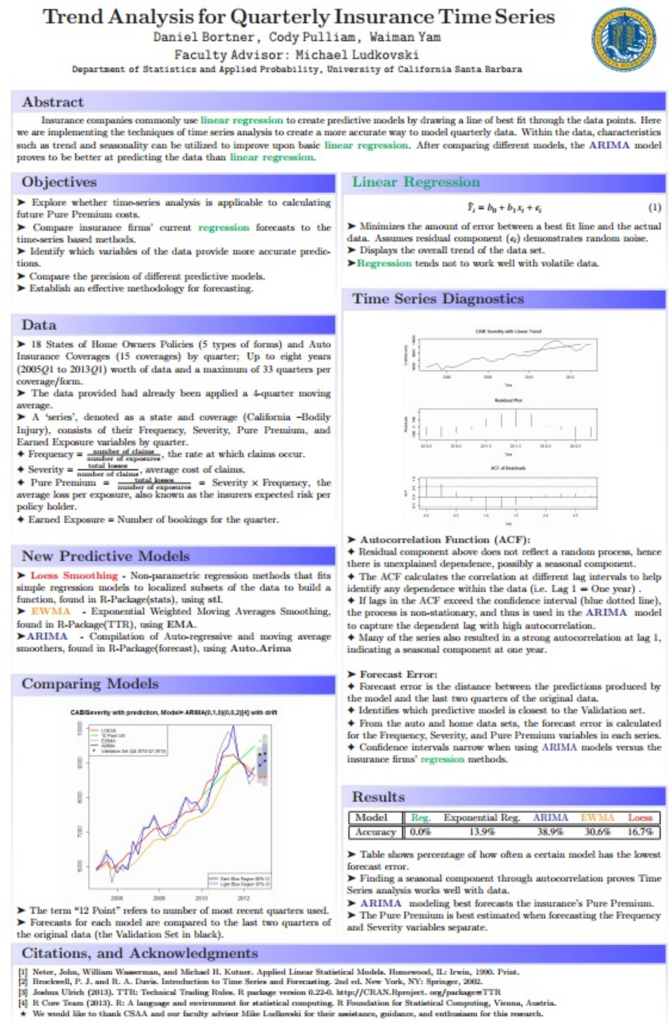
- The only Center of Actuarial Excellence on the West Coast and one of 17 CAE programs in US
- The most comprehensive program in CA
- Unique 5-year combined program BS/MS in ActSci
- Prize winning UG *Research Projects in Actuarial Science*
- UCSB Actuarial Program Advisory Board
- Annual Actuarial Career Fair
- Annual Actuary Day
- Actuarial Visitor Program
- Center for Financial Mathematics and Actuarial Research
- California Actuarial Student Summit 2015, 2017
- Courses cover 5 preliminary SOA/CAS exams
- SOA-approved courses for all VEE subjects

Actuarial Offerings

- Usual 4-year Bachelor degree in Actuarial Science
- Unique 5-year Master degree; a Masters for students with a UCSB Actuarial Science Bachelor degree for one additional year of graduate school
- Graduate program includes research (more of that later)

Undergraduate Actuarial Research

- Actuarial Research Projects:
  - **2010-2011: AAA NCNU**
  - **2011- 2012: Towers Watson**
  - **2012-2013: Solucia Inc.**
  - **2012-2013: Towers Watson**
  - **2013-2014: CSAA**
  - **2013-2014: Towers Watson**
  - **2013-2014: Blue Shield**
  - **2014-2015: CSAA**
  - **2014-2015: William Sansum Diabetes Center**
  - **2015-2016: Vitality Group (Health &Fitness)**
  - **2015-2016: Allstate (Auto; hand-held devices)**
  - **2015-2016: Cottage Hospital (Readmissions)**



Trend Analysis for Quarterly Insurance Time Series

Daniel Bortner, Cody Pulliam, Waiman Yam
Faculty Advisor: Michael Ludkovski
Department of Statistics and Applied Probability, University of California Santa Barbara

Abstract

Insurance companies commonly use linear regression to create predictive models by drawing a line of best fit through the data points. Here we are implementing the techniques of time series analysis to create a more accurate way to model quarterly data. Within the data, characteristics such as trend and seasonality can be utilized to improve upon basic linear regression. After comparing different models, the ARIMA model proves to be better at predicting the data than linear regression.

Objectives

- Explore whether time-series analysis is applicable to calculating future Pure Premium costs.
- Compare insurance firms' current regression forecasts to the time-series based methods.
- Identify which variables of the data provide more accurate predictions.
- Compare the precision of different predictive models.
- Establish an effective methodology for forecasting.

Data

- 18 States of Home Owners Policies (5 types of forms) and Auto Insurance Coverages (15 coverages) by quarter; Up to eight years (2005$Q1$ to 2013$Q1$) worth of data and a maximum of 33 quarters per coverage/form.
- The data provided had already been applied a 4-quarter moving average.
- A 'series', denoted as a state and coverage (California –Bodily Injury), consists of their Frequency, Severity, Pure Premium, and Earned Exposure variables by quarter.
  - Frequency = $\frac{\text{number of claims}}{\text{number of exposures}}$, the rate at which claims occur.
  - Severity = $\frac{\text{total losses}}{\text{number of claims}}$, average cost of claims.
  - Pure Premium = $\frac{\text{total losses}}{\text{number of exposures}}$ = Severity × Frequency, the average loss per exposure, also known as the insurers expected risk per policy holder.
  - Earned Exposure = Number of bookings for the quarter.

New Predictive Models

- Loess Smoothing - Non-parametric regression methods that fits simple regression models to localized subsets of the data to build a function, found in R-Package(stats), using stl.
- EWMA - Exponential Weighted Moving Averages Smoothing, found in R-Package(TTR), using EMA.
- ARIMA - Compilation of Auto-regressive and moving average smoothers, found in R-Package(forecast), using Auto.Arima

Comparing Models

CABISeverity with prediction, Model= ARIMA(0,1,0)(0,0,2)[4] with drift

- The term "12 Point" refers to number of most recent quarters used.
- Forecasts for each model are compared to the last two quarters of the original data (the Validation Set in black).

Linear Regression

$$\hat{Y}_i = b_0 + b_1 x_i + \epsilon_i \tag{1}$$

- Minimizes the amount of error between a best fit line and the actual data. Assumes residual component (ϵ_i) demonstrates random noise.
- Displays the overall trend of the data set.
- Regression tends not to work well with volatile data.

Time Series Diagnostics

- **Autocorrelation Function (ACF):**
  - Residual component above does not reflect a random process, hence there is unexplained dependence, possibly a seasonal component.
  - The ACF calculates the correlation at different lag intervals to help identify any dependence within the data (i.e. Lag 1 = One year) .
  - If lags in the ACF exceed the confidence interval (blue dotted line), the process is non-stationary, and thus is used in the ARIMA model to capture the dependent lag with high autocorrelation.
  - Many of the series also resulted in a strong autocorrelation at lag 1, indicating a seasonal component at one year.
- **Forecast Error:**
  - Forecast error is the distance between the predictions produced by the model and the last two quarters of the original data.
  - Identifies which predictive model is closest to the Validation set.
  - From the auto and home data sets, the forecast error is calculated for the Frequency, Severity, and Pure Premium variables in each series.
  - Confidence intervals narrow when using ARIMA models versus the insurance firms' regression methods.

Results

Model	Reg.	Exponential Reg.	ARIMA	EWMA	Loess
Accuracy	0.0%	13.9%	38.9%	30.6%	16.7%

- Table shows percentage of how often a certain model has the lowest forecast error.
- Finding a seasonal component through autocorrelation proves Time Series analysis works well with data.
- ARIMA modeling best forecasts the insurance's Pure Premium.
- The Pure Premium is best estimated when forecasting the Frequency and Severity variables separate.

Citations, and Acknowledgments

[1] Neter, John, William Wasserman, and Michael H. Kutner. Applied Linear Statistical Models. Homewood, IL: Irwin, 1990. Print.
[2] Brockwell, P. J. and R. A. Davis. Introduction to Time Series and Forecasting. 2nd ed. New York, NY: Springer, 2002.
[3] Joshua Ulrich (2013). TTR: Technical Trading Rules. R package version 0.22-0. http://CRAN.Rproject. org/package=TTR
[4] R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

★ We would like to thank CSAA and our faculty advisor Mike Ludkovski for their assistance, guidance, and enthusiasm for this research.

Undergraduate Actuarial Research

Auto Frequency Trend & Hand-Held Devices

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Faculty Advisor: Janet Duncan
Department of Statistics and Applied Probability, University of California Santa Barbara

Abstract

During Phase I of our project, we concluded that accident frequency has been increasing in recent years and cell phone usage is at an all-time high. However, we were unable to establish a concrete positive correlation between the two, as there are many other confounding factors that also affect accident frequency. We created a model to estimate the impact that handheld devices have on auto accident frequency and auto premiums. This can be used to then estimate the potential savings of implementing an involuntary cell phone blocking device.

Phase I

- Auto insurance companies have been experiencing an uptick in auto accident frequencies since 2012. We compared cell phone use and auto accidents to estimate their relationship.
- According to industry data, auto accident frequency decreased from 2000-2012 and increased from 2012-2015. Normalizing for miles driven, the accident frequency flattens.
- Without the knowledge of in-vehicle use, cell phone data was more difficult to come by. We were able to find publicly available information on cell phone subscriptions which showed an increase over the last 20 years.
- The yearly increase in cell phone subscriptions was inconsistent with the decrease, and subsequent increase, in auto accident frequency. This could be due to other factors increasing and decreasing auto accident frequency over time, such as weather, car and road improvements, etc.

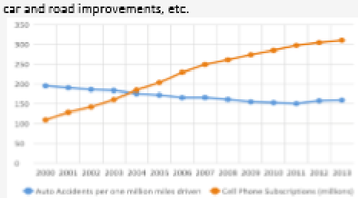

Figure 1: The number of police reported auto accidents per one million miles driven compared to cell phone subscriptions in millions in the United States from 2000-2013 (Sources: U.S. Department of Transportation – National Highway Traffic Safety Administration; International Telecommunications Union)

Phase I Limitations

- We only used publicly available data which might not align with Allstate data
- Information on in-vehicle cell phone use was limited. One of the few metrics we were able to find was on the number of cell phone subscriptions.
- Inconsistencies of police reports record cell phone use.
- Multiple causes of accidents

Research Results

- In general, cell phones impact 1.12% of the auto premium. With a $900 premium this translates to $10.05.
- This analysis was based on "average" assumptions for drivers and auto premium. Limitations of publicly available data make it difficult to model the impact based on driver characteristics. However, some insurance companies may have more detailed data which could enhance a similar analysis.

Citations & Acknowledgements

NHTSA Study

- The purpose of this study was to investigate the effects of cell phone distraction.
- Data was collected from 204 drivers over 31 days in 2011.
- Only drivers who reported talking on a cell phone while driving at least once per day were recruited.
- Drivers were video recorded to analyze which type of cell phone activity was performed and how long it was performed for.
- Determined texting/browsing and looking for a cell phone when receiving a call were significantly dangerous.
- These activities accounted for 1.1% of driving time and increased the relative risk of an accident by 1.82 times.
- Using that, we determined that for cell phone users, 1.98% of accidents occur while being on the phone.
- Recorded in terms of safety critical events. In order to use this information, we assumed that the relative rate of accidents to safety critical events was independent of phone use.

Key Industry Figures

- AT&T Survey: Determined that 70% of people use their phone use driving. To make the definitions of phone use comparable, we made the assumption that people are unable to properly estimate their daily phone use and are either willing or not willing to use their phones while driving.
- Allstate Company Data: Looking at Allstate's annual and quarterly reports, we determined a loss ratio of 0.69 and an average premium of $900.
- Insurance Information Institute: 12.6% of expected losses are from other than collision claims. We excluded these because they are not affected by phone use. This left us with 87.3% of expected losses are affected by phone use.

Model

- We made an adjustable model using our assumptions. This would allow a company to plug in their own numbers to see how much their policyholders could save.

Predictive Modeling of Healthcare Costs using Regression Trees

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Abstract

The ongoing healthcare insurance reform under the Affordable Care Act (ACA) of 2010 makes it critical for insurers to engage in predictive modeling to control adverse selection and other concerns related to ACA. Few actuarial studies are currently publicly available on this subject. Using a unique dataset from a private insurer on 20,000 individuals we investigated predictability of next-year costs based on 133 current-year covariates for each covered member. Our predictor variables included basic demographic information, categorized insurance costs for current year, as well as over 80 Hierarchical Condition Categories (HCCs), listing medical conditions that triggered previous expenses. To tackle the large number of covariates and the highly nonlinear nature of healthcare costs, we utilized hierarchical statistical regression methods. In particular, we focused on Regression Trees (CART) and its extension Random Forests. A variety of different models, including gender-specific and demographics-only were fitted and validated. We also studied predictive power of the models for specific risk groups and statistical evidence regarding most important covariates. Our analysis shows that Random Forest is a promising method for predictive modeling, providing best performance across a range of other regression methods we tried. We also found that surprisingly HCCs carry little statistical significance compared to information about actual claims incurred. This work is related to Mackenzie, Sun and Wu (2013) who studied the same dataset using MARS regression.

An Example
Automobile Territories

- A project for a California insurer involved the use of statistical clustering methods to identify automobile rating territories
- Students applied three different methods, making use of insurer data and the R programming language
- Students also learned communication skills when they needed to present their results to insurer management at the insurer's offices
- They also presented their results in a poster session at UCSB's Undergraduate Research Colloquium
- Students visited the sponsoring company, submitted a written report and gave a presentation

UCSB Actuarial Advisory Board

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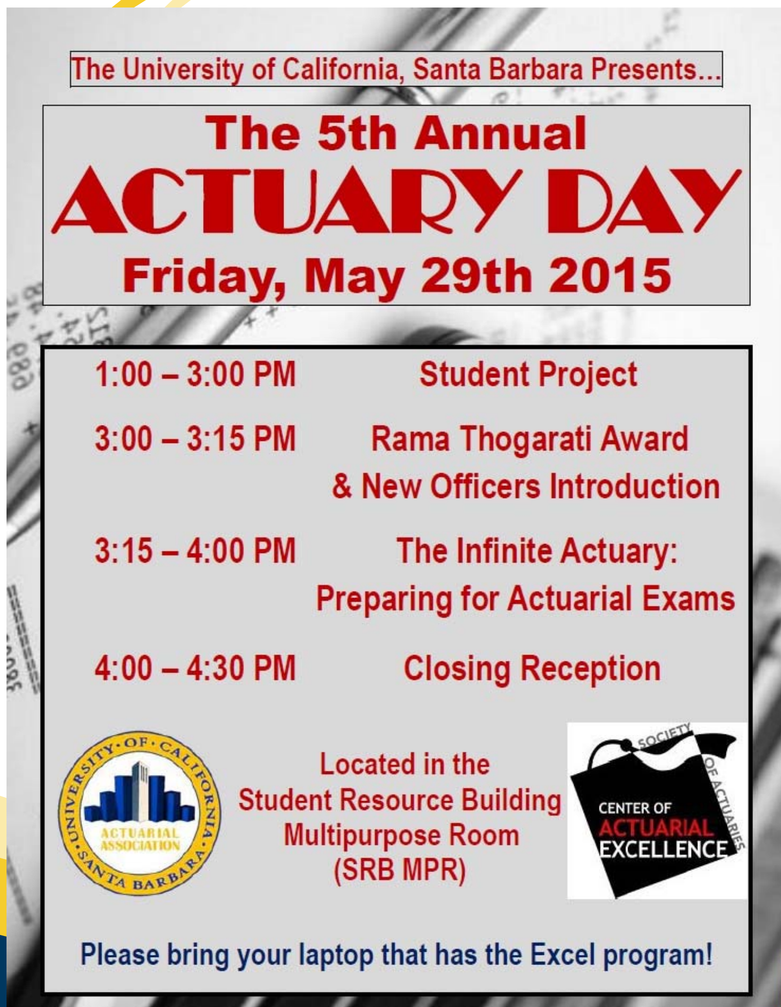
UCSB Actuarial Association

ucsbactuary.org

- Job & internship recruitment
- Educational workshops
- Excel Workshops
- Resume Workshops
- Exam Reimbursement

2016-17 Actuary Association Officers

Actuary Day

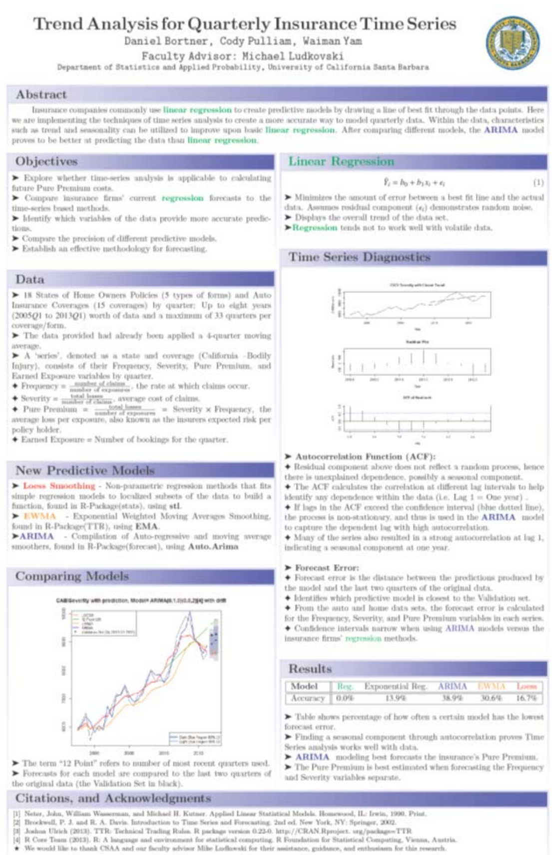

The University of California, Santa Barbara Presents…
The 5th Annual
ACTUARY DAY
Friday, May 29th 2015
1:00 – 3:00 PM Student Project
3:00 – 3:15 PM Rama Thogarati Award & New Officers Introduction
3:15 – 4:00 PM The Infinite Actuary: Preparing for Actuarial Exams
4:00 – 4:30 PM Closing Reception
University of California · Santa Barbara · Actuarial Association
Located in the Student Resource Building Multipurpose Room (SRB MPR)
Society of Actuaries
Center of Actuarial Excellence
Please bring your laptop that has the Excel program!

California Actuarial Student Conference 2015, 2017

ARC 2014
Hosted by UCSB

Poster Prize Winner ARC 2014

- One among many student research projects
- Considered measurement of trend using quarterly data
- Presented as a poster session at the 2014 Actuarial Research Conference
- Was awarded first prize (jointly) for poster sessions



Taking Advantage of CAS Opportunities

- **UCSB students have consistently taken advantage of CAS opportunities when available**
- **A contingent of UCSB students attended student sessions at the 2014 CLRS**
- **UCSB students are frequent visitors at meetings of the Southern California Casualty Actuaries Club**
- **UCSB students took advantage the convenient location of ARC 2014 to both attend and participate**

2016 Actuarial Career Fair