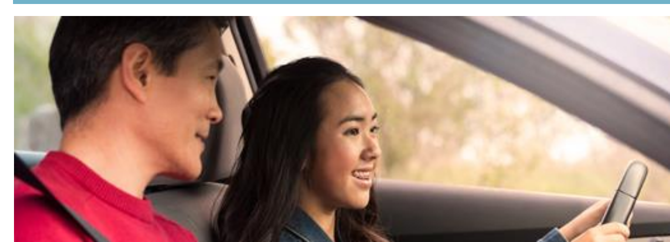
Applications of Price Elasticities in Auto Insurance

2014 Actuarial Research Conference

Philip Wong
Actuarial Research
CSAA Insurance Group
July 16, 2014



Introduction

- Many statistical modeling textbooks concentrate on theoretical concepts and less on data issues and ambiguities that arises in business analysis
- We will look at price elasticity (demand) models and the challenges of applying them to premium dislocation analysis
- Outline of presentation:
  - Business needs for elasticity models
  - Discrete choice model theoretical framework
  - Observation of a “large” premium decrease
  - Applying elasticity models to premium dislocation analysis
  - Elasticity estimates
  - Further issues in modeling elasticities

Elasticity Models - Introduction

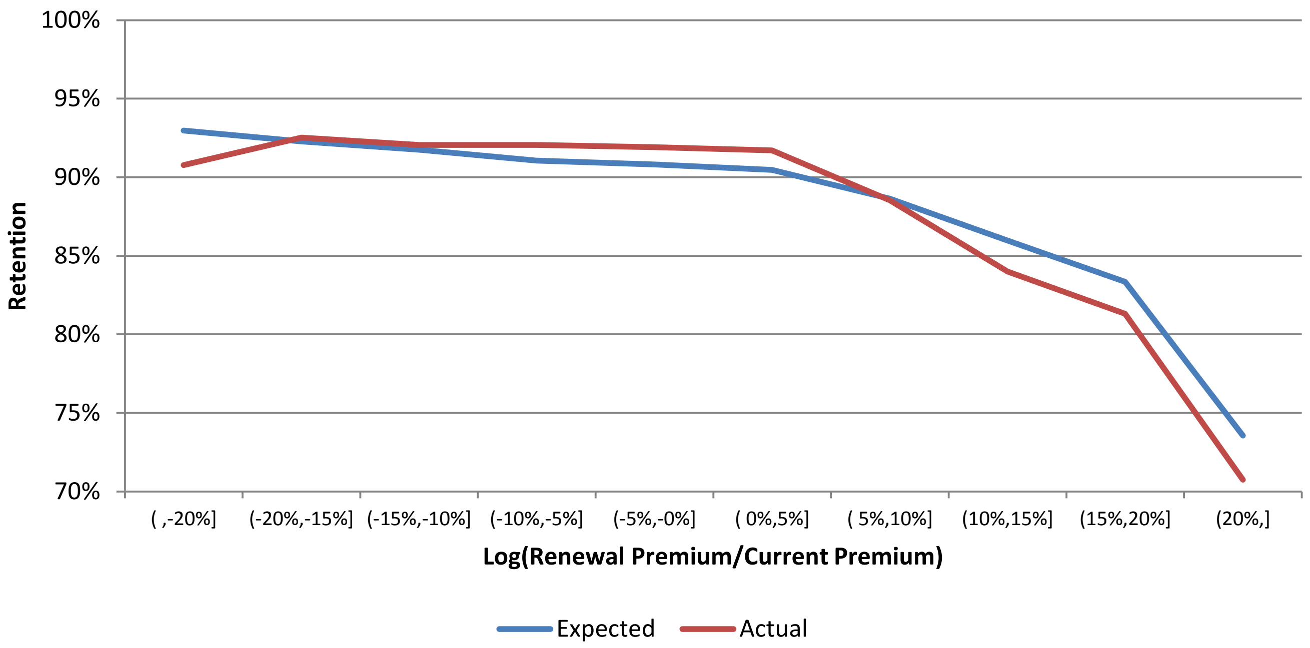
- Elasticity (or Demand) Models estimate the change in quantity given a change in price (premium)
  - Quantity Change
    - Renewals/retention ratios for policies-in-force
    - Quote close ratios for new business
  - Premium Change
    - Rate change, aging, stochastic
- Businesses would like to know the effects of rate changes on policy counts and total premiums to assist in strategic planning and forecasting
- Examples are based on 6 month auto policies for 6 states and one rate change in 2013

Theoretical Framework: Discrete Choice Models

- Discrete Choice Analysis is an approach to study consumer choice – given a finite number of choices and their attributes, the model predicts the probability of each individual's choice
- We assume the insured has
  - Two choices – either renew or not; accept quote offer or reject
  - One attribute that varies with choice (premium)
- In estimating models, we use logit link
- References: McFadden (1974), Train (1996)

Actual Retention by Premium Change

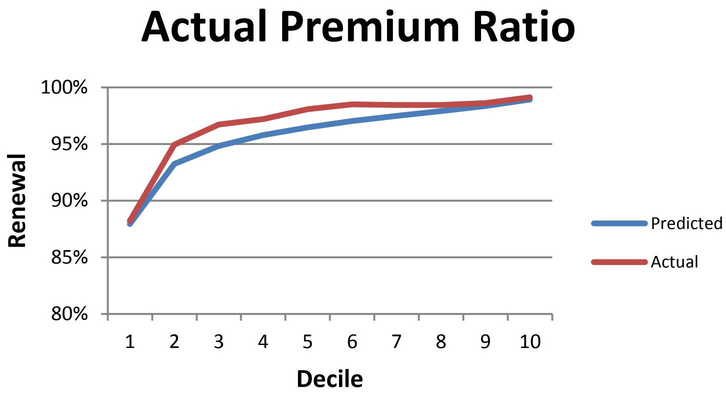
- We generally expect that the higher renewal premium relative to current premium, the lower the expected retention
- But, that is not true for large premium decreases -- actual retention rates decrease
- We see this phenomenon appearing across different areas and time periods

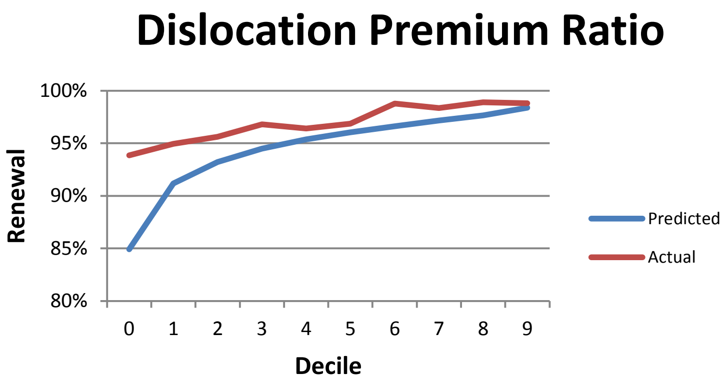


Application: Premium Dislocation

- Premium dislocation analysis compares the before and after premiums due to a rate change assuming the same policy characteristics
- This appears to be an ideal application for elasticity models in estimating impact of a rate change
- Timing lags are challenges to our current process:
  - Detailed policy characteristics datasets are created only twice a year
  - Takes a long time to validate retention – e.g. for annual policies, need to wait two years after the rate plan effective date to capture the full policy year impact
- Example: Apply renewal model to a state rate filing in May 2013
  - Validate by calculating estimated renewal rate deciles and compare with actual renewal rates
  - Premium dislocation data is as mid year 2012

Application: Model Validation



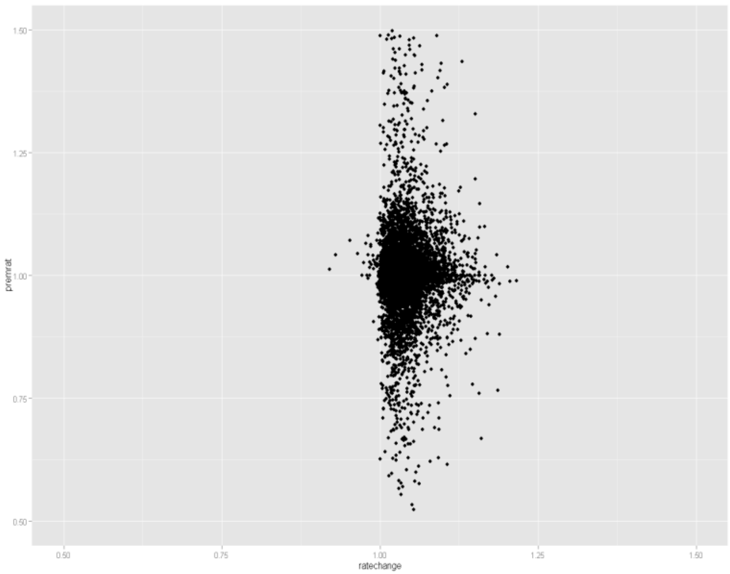


- Above charts are based on policies that came up for renewal after the rate change and were used in the premium dislocation analysis
- The model performs well on actual premiums but not so well on dislocation data

Application: Premium Dislocation

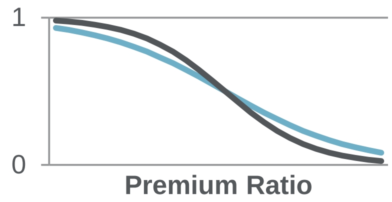
- The above premium ratios are fairly uncorrelated:

Renewal Prem/ Current Prem	Mean	Std Dev	Correlation
Actual	1.01	0.11	
Prem Dislocation	1.04	0.03	0.00



Elasticity Definitions

- Elasticity (%Δ quantity/%Δ price)
  - Arc Elasticity: $\{(Q_2-Q_1)/[(Q_1+Q_2)/2]\}/\{(P_2-P_1)/[(P_1+P_2)/2]\}$
  - Elasticity (Discrete): $\{(Q_2-Q_1)/Q_1\}/\{(P_2-P_1)/P_1\}$
  - Point Elasticity: $(\partial Q/Q)/(\partial P/P) = \partial \ln(Q)/\partial \ln(P)$
- Calculate elasticity at the policy or quote level
- Elasticity varies across policies (given premium)
- Elasticity also depends on premium level (given policy)



- Retention elasticity estimates below are based on auto six month policies for six states

Elasticity Estimates

	Retention		Quotes/New business	
	Mean	Standard Deviation	Mean	Standard Deviation
Point elasticity (current prem)	-0.28	0.20	-0.96	0.50
Arc elasticity (90% current & current)	-0.24	0.17	-0.91	0.49
Arc elasticity (current & 110% current)	-0.32	0.22	-0.93	0.50
Elasticity (90% current & current)	-0.22	0.16	-0.81	0.43
Elasticity (current & 110% current)	-0.30	0.20	-0.84	0.44

- New business is several times more elastic than retention
- Elasticity's variance is fairly large
- Elasticity depends on particular definition

Further Issues

- Handle 6 and 12 month policies together (survival analysis, discrete logistic regression)
- Distinguish between different sources of premium changes (identify premium changes coming from deterministic [e.g. aging], stochastic [e.g. violations], and rate changes
- Calculating competitor premiums need many assumptions to run a vendor's program
- Frequency in updating models (e.g. retention validation on a rate change takes long time)

Summary

- Business knowledge is needed to develop and apply models useful to business needs. Challenges include:
  - Define business data fields in terms of modeling statistical variables
  - Adapt to business' data processes and limitation
  - Communicating methodology and results to non-technical audiences
- Elasticity results
  - Retention less elastic than new business quotes
  - Auto less elastic than homeowners (not shown here)

Reference

McFadden, D. (1974), “Conditional Logit Analysis of Qualitative Choice Behavior,” in Frontiers in Econometrics, ed. P. Zarembka, New York: Academic Press

Train, K. (2003, 2009). Discrete Choice Methods with Simulation, Cambridge University Press

Appendix

Appendix – Binary Model

Assume 2 possible choices and V is linear in parameters with logit link:

$V_{in} = \beta_1 x_{in1} + \beta_2 x_{in2} + \ldots + \beta_k x_{ink}$

$V_{jn} = \beta_1 x_{jn1} + \beta_2 x_{jn2} + \ldots + \beta_k x_{jnk}$

$P_{in} = \exp(V_{in})/[(\exp(V_{in})+\exp(V_{jn})]$

$= \exp(\beta' x_{in})/[(\exp(\beta' x_{in})+\exp(\beta' x_{jn})]$

$= 1/(1 + \exp(\beta'(x_{in}-x_{jn})))$

Example: let i=1=CSAA IG; j=2=Competitor, n is insured

Appendix – Point Elasticity

Elasticity Calculation:

$E(P_{in},x_{ink}) = (1-P_{in})*\beta_k *\partial V_{in}/\partial x_{ink}*x_{ink}$

$E(P_{in},x_{jnk}) = -P_{in}*\beta_k *\partial V_{in}/\partial x_{jnk}*x_{jnk}$

In our example, $V_{in} = \ln(x_{in})$, so

$E(P_{in},x_{ink}) = (1-P_{in})*\beta_k$

$E(P_{in},x_{jnk}) = -P_{in}*\beta_k$

i = choice, n = insured, k = variable in model

Appendix – Auto Models

- Important Variables in Auto Retention/Renewal Model:
  - Renewal premium ratio, competitor premium ratio, multipolicy discount, state, age of oldest insured, auto persistency
- Important Variables in Auto Quote Model:
  - Competitor premium, policy term, number of drivers, number of vehicles, bi limit, payment method, median age