



Society of Actuaries in Ireland

Non Life Pricing Seminar
Topical Actuarial Perspectives

Wednesday – 21st March, 2018

Radisson Blu Golden Lane Hotel

Agenda – Non-Life Pricing Seminar 2018

Time	Title	Speakers
8:30 – 8:35	Welcome	Cecilia Cheuk
8:35 – 9:20	Machine Learning	Duncan Anderson
9:20 – 10:05	Advanced Modelling Techniques for General Insurance Claims Data	Adrian O’Hagan/Sen Hu
10:05 – 10:25	Coffee Break	
10:30 – 11:15	Parallel Sessions	
	A. Commercial Lines Pricing Techniques	Eoin O’Baighill
	B. Current hot-topics in Personal Lines Pricing	Jenny Quigley
11:20 – 12:50	Professionalism	
	“YouCanNotLose” <i>(Volunteers: Aidan Redmond, Grainne Murray, Jenny Johnston, Mark McCormick, Shane Walsh)</i>	Neil Hilary
	“ambiguous illusion”	Cecilia Cheuk
12:50 - 13:00	Closing	Cecilia Cheuk

Disclaimer:

The material, content and views in the following presentation are those of the presenter(s).



Competition Law Awareness



Please be mindful when you are participating in any discussions during this seminar.

Duncan Anderson, MA FIA



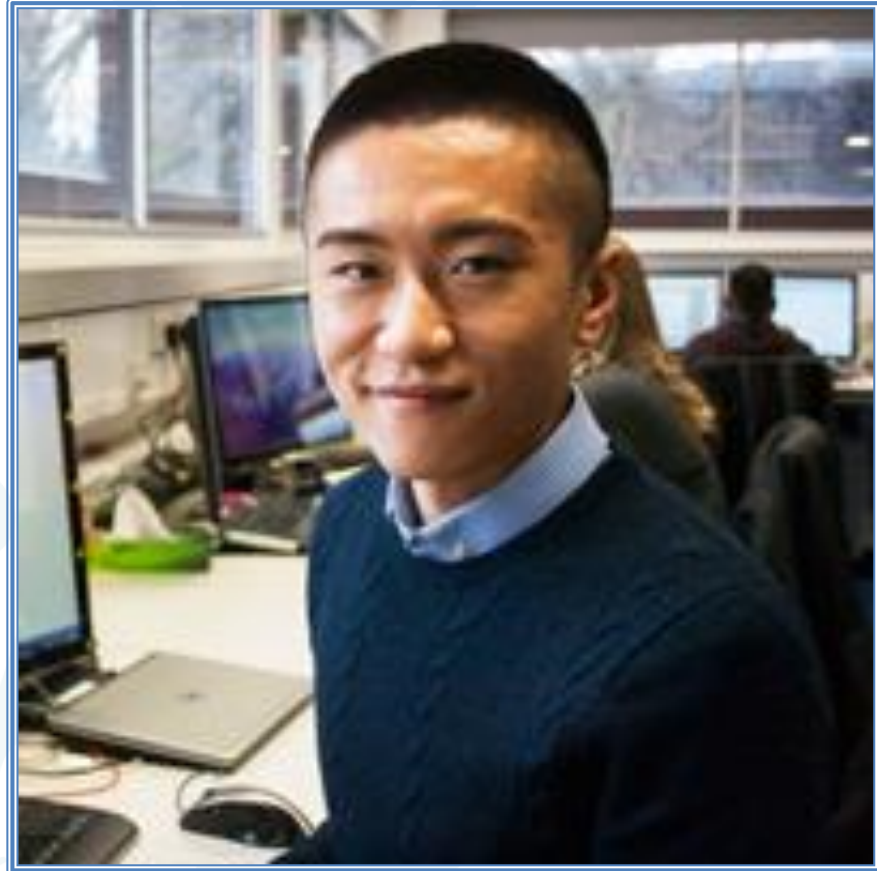
- **Managing Director, WTW**
- **Global Leader for Insurance Technology**
- **Professional activities**
 - IFoA GI Board
 - IFoA GRIP Taskforce
 - IFoA GI Pricing Seminars
- **"A Practitioner's Guide to Generalized Linear Models"**

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UCD Insight - Centre for Data Analytics



Dr. Adrian O'Hagan



Sen Hu, MSc

*University of Edinburgh
Imperial College London*



Empowering Citizens. Smarter Societies.

Advanced Modelling Techniques for General Insurance Claims Data

SAI pricing seminar

Mr Sen Hu, Dr Adrian O'Hagan, Prof T. Brendan Murphy

A World Leading SFI Research Centre

Introduction



- Background: *Insight Centre for Data Analytics*
- Project objectives
- Factor collapsing with Bayesian model averaging (FCBMA)
- Conclusion

Insight Centre for Data Analytics

- The largest Science Foundation Ireland founded research organization
- One of Europe's largest data analytics research organizations
- Four centres: Insight@UCD, Insight@DCU, Insight@NUI Galway and Insight@UCC
- Outward facing research with strong industry links!



Machine
Learning &
Statistics



Semantic Web



Linked Data



Media
Analytics



Optimisation &
Decision
Analysis



Personal
Sensing



Recommender
Systems

Two data sets are considered:

Illustrative set:

- Third party motor insurance claims data in Sweden in 1977 from Faraway (2016)
- 1797 observations
- 4 factors: Kilometers, Zone, Bonus, Make

Real industry set:

- Insurance claims history data from an Irish motor insurer from January 2013 to June 2014
- Accidental damage (within comprehensive cover) is analyzed only.

(A priori) Ratemaking model

Let N be the number of claims, Y be the claim size per claim, X be the observations.

$$\begin{aligned} &\text{Expected claim size} = \text{Pure premium} \\ &= E(N|X) * E(Y|N > 0, X) \end{aligned}$$



Frequency **Severity**

Motivating issues (from the Sweden data):

- Model 1:

$$\log(\text{Claims}) = \beta_0 + \beta_1 \text{Make} + \beta_2 \text{Bonus} + \beta_3 \text{Zone} + \beta_4 \text{Kilometers}$$

- Model 2:

$$\log(\text{Claims}) = \beta_0 + \beta_1 \text{Make} + \beta_2 \text{Bonus} + \beta_3 \text{Zone}$$

Could we combine the two models?

Motivating issues (from the Sweden data)

$$\log(\text{Claims}) = 8.395 + \beta_1 \text{ Make} + \beta_2 \text{ Bonus} + \beta_3 \text{ Zone}$$

+ Kilometers1 *	0.00	← baseline
+ Kilometers2 *	0.02	← p-value: 0.057
+ Kilometers3 *	0.02	← p-value: 0.153
+ Kilometers4 *	0.04	← p-value: 0.038
+ Kilometers5 *	0.04	← p-value: 0.074

Could we combine (some of) these categories?

Three motivating questions:

1

- Should a categorical predictor be included in modelling?

2

- When included, should certain levels be merged together?

3

- When included and with certain levels merged, how much confidence should be placed on this clustering of levels and this model?

What can we do about it using current methods?

Collapse categories

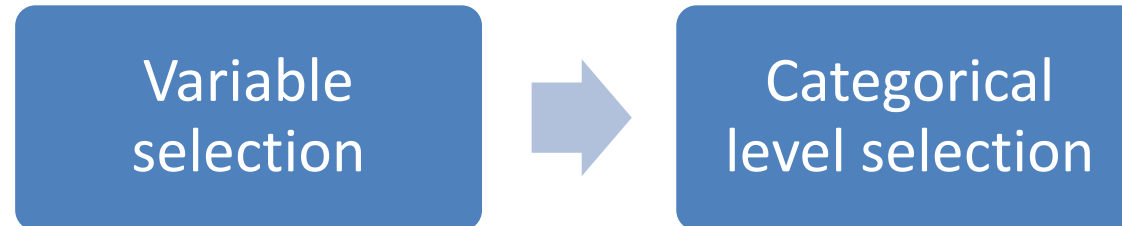
- CART: classification and regression tree
- Pairwise multiple comparison with general linear hypothesis in GLM (Hothorn et al, 2008)
- Regularization methods such as lasso, OSCAR (Gertheiss & Tutz, 2010)
- Model-based clustering with Bayesian MCMC framework (Malsiner-Walli et al, 2017)
- Method in “BMA” package in R (Raftery et al., 2015)

Keep all categories

- Generalized linear mixed models
- Combining GLM and credibility theory (Ohlsson & Johansson, 2008)

Method outline:

- Factor collapsing (FC) assesses which categories differ from one another with respect to the response
- There is uncertainty about the optimal combination
- Bayesian model averaging (BMA) takes such uncertainty into consideration



Bayesian model averaging (BMA)

Use BMA to average the best models (where possible) (Hoeting et al. 1999)

Model weights can be calculated directly using BIC:

$$BIC = -2 * \hat{l} + \ln n * k$$

$$\Pr(M_k|D) \approx \frac{\exp(-0.5 BIC_k) \Pr(M_k)}{\sum_{r=1}^K \exp(-0.5 BIC_r) \Pr(M_k)}$$

$\Pr(M_k)$ is the prior for each model

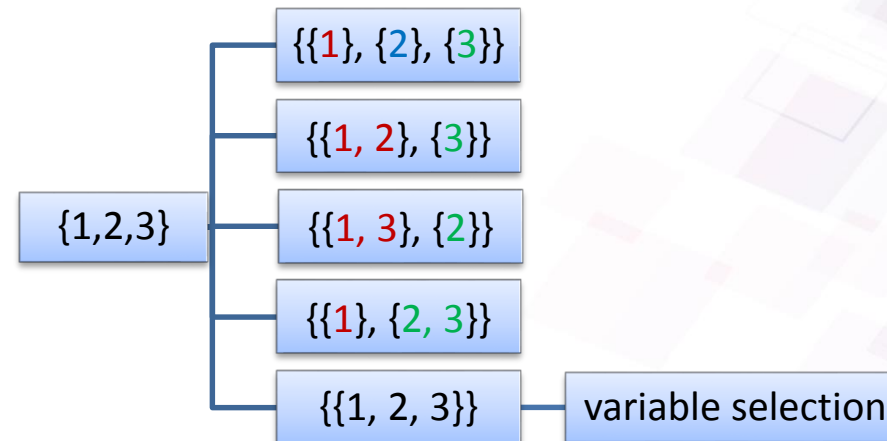
Average over model predictions

Factor collapsing (FC)

Set partitions:

grouping elements in a set into non-empty subsets such that every element is included in one and only one subset

Partitioning a 3-element set:

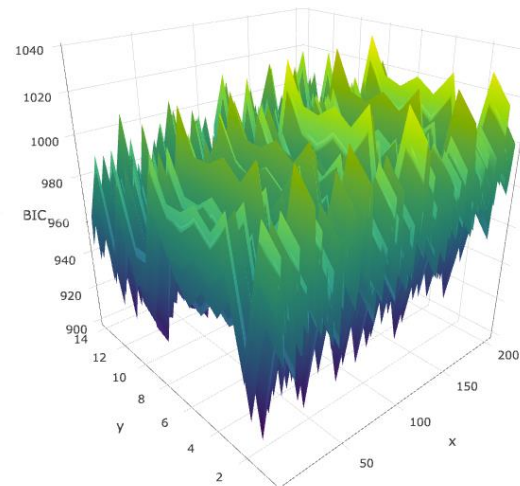


Bell number increases super exponentially!

Stochastic search

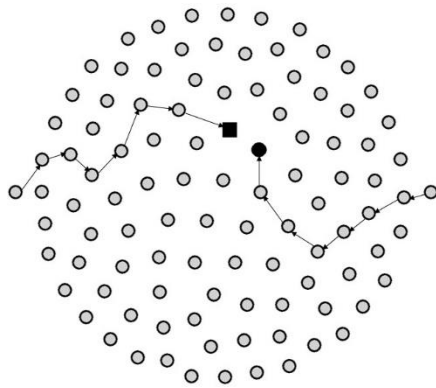
Number of set partitions increases super exponentially

- Computationally very intensive
- Model selection problem becomes an **optimization problem!**
- Stochastic search over combinatorial states
- Many stochastic optimization methods work for this bumpy objective function:
 - **Simulated annealing**
 - **Genetic algorithm**
 - ...

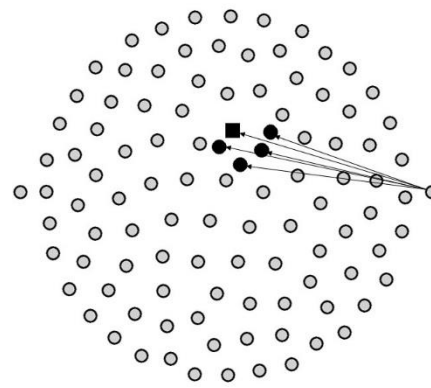


FC-BMA illustration

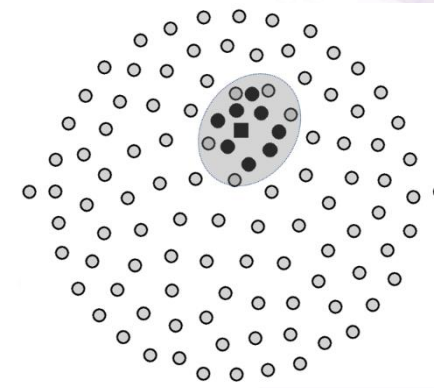
Comparing FC-BMA with stepwise selection using BIC or AIC



Forward and backward selection








FC-BMA



Optimal model region

Follow up to the previous Sweden data example...

Predictor “vehicle make” in the **frequency model**: model summary

	Coefficient	p-value
⋮		
 Make 4	-0.641	<0.05 (***)
 Make 6	-0.331	<0.05 (***)
 Make 3	-0.226	<0.05 (***)
 Make 9	-0.070	<0.05 (***)
 Make 7	-0.045	0.06 (.)
 Make 8	-0.008	0.80
 Make 1	0	
 Make 2	0.086	<0.05 (***)
 Make 5	0.162	<0.05 (***)
⋮		
⋮		

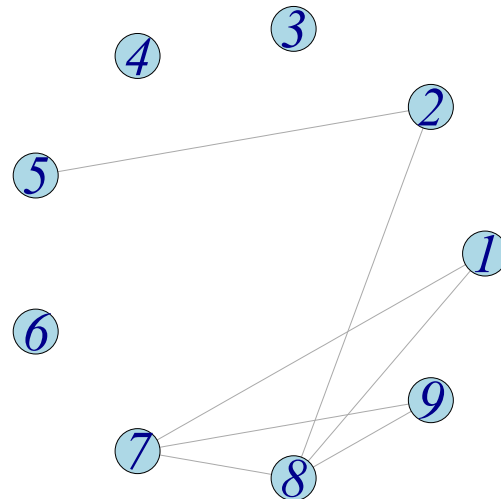
Follow up to the previous Sweden data example...

Predictor “Make” in the frequency model: results of multiple comparison using R package “multcomp” (Hothorn et al., 2016)

Hypothesis	Adjusted p-value
7 - 9 == 0 : coefficients of levels 7 and 9 equivalent	0.9583
8 - 9 == 0 : coefficients of levels 8 and 9 equivalent	0.4909
7 - 1 == 0 : coefficients of levels 7 and 1 equivalent	0.5600
8 - 1 == 0 : coefficients of levels 8 and 1 equivalent	1.0000
5 - 2 == 0 : coefficients of levels 5 and 2 equivalent	0.0839
8 - 2 == 0 : coefficients of levels 8 and 2 equivalent	0.1429
8 - 7 == 0 : coefficients of levels 8 and 7 equivalent	0.9837

Follow up to the previous Sweden data example...

Predictor “Make” in the frequency model: results of multiple comparison using R package “multcomp” (Hothorn et al., 2016)



Follow up to the previous Sweden data example...

Results for collapsing “Make” factor only in the frequency model. Here only the best 5 models (based on their BIC values) are shown.

Partitions	BIC	BMA weights
(1,8)(2)(3)(4)(5)(6)(7,9)	10,301.11	0.3458
(1,8)(2,5)(3)(4)(6)(7,9)	10,301.81	0.2426
(1,7,8)(2)(3)(4)(5)(6)(9)	10,303.44	0.1076
(1,7,8)(2,5)(3)(4)(6)(9)	10,304.15	0.0754
(1)(2)(3)(4)(5)(6)(7,8,9)	10,304.92	0.0514

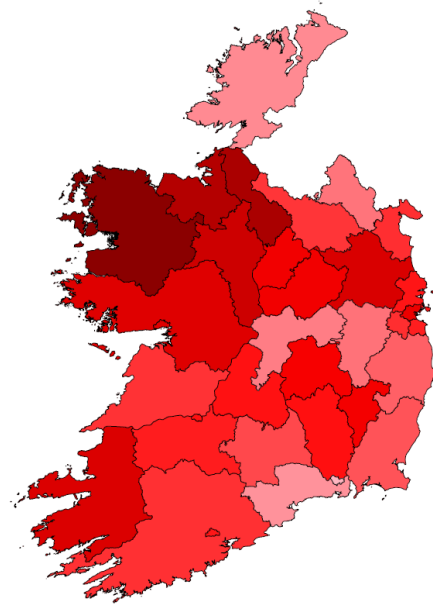
Follow up to the previous Sweden data example...

Results for collapsing “Kilometers” factor only in the severity model. Here only the best 5 models (based on their BIC values) are shown.

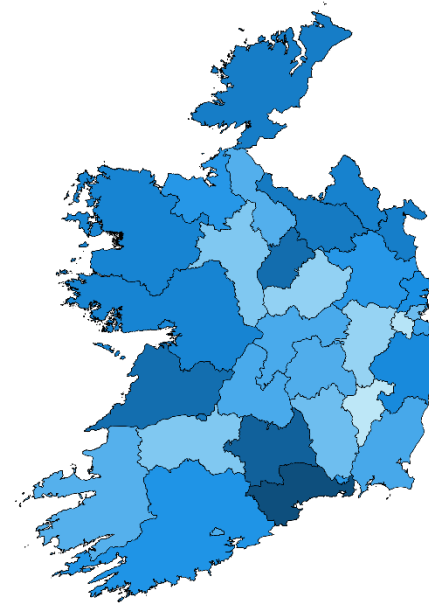
Partitions	BIC	BMA weights
(1)(23)(45)	1,878,161	0.8124
(1)(2)(3)(45)	1,878,164	0.1430
(1)(23)(4)(5)	1,878,167	0.0379
(1)(2)(3)(4)(5)	1,878,170	0.0067
(1)(25)(3)(4)	1,878,198	0.0000

Irish GI insurer data: counties

Coefficients of Irish counties from the standard GLM over an Irish map:



Frequency



Severity

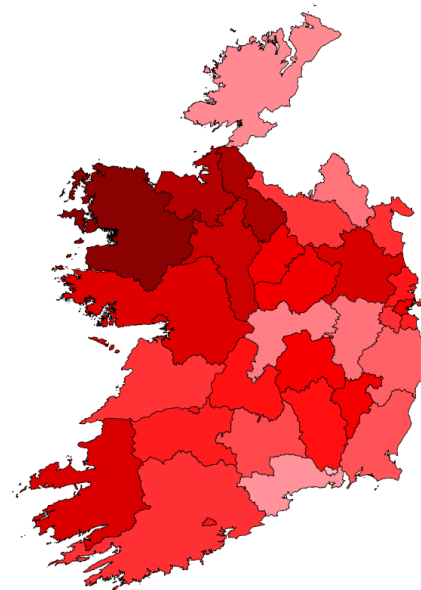
Irish counties clustering

(Subset of) frequency model coefficients for the standard GLM and results of FC-BMA. Categories are of increasing order based on standard GLM coefficients. Only four models are selected for illustration.

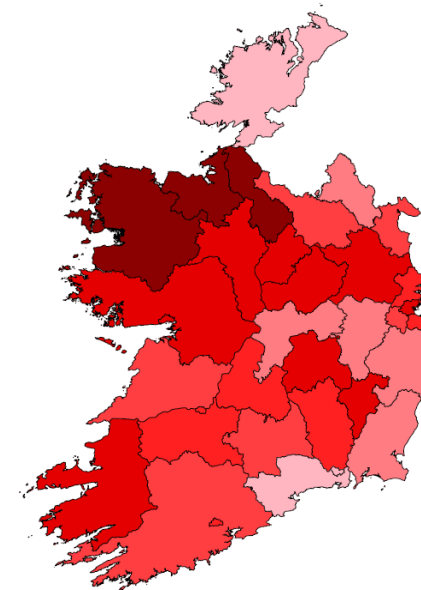
	Std. GLM	BMA	Model 1	Model 2	Model 3	Model 4
BIC			62,807.29	62,807.30	62,807.40	62,807.41
Model weights			0.0233	0.0232	0.0221	0.0220
Waterford City	-6.66	-6.64	-6.64	-6.64	-6.63	-6.63
Unknown	-6.61	-6.64	-	-	-	-
Waterford County	-6.61	-6.64	-	-	-	-
Donegal County	-6.60	-6.64	-	-	-	-
Offaly County	-6.58	-6.62	-6.57	-	-	-
Monaghan County	-6.57	-6.61	-	-6.57	-	-
Kildare County	-6.56	-6.57	-	-	-6.57	-6.57
Wicklow County	-6.54	-6.57	-	-	-	-
Wexford County	-6.52	-6.57	-	-	-	-
South Tipperary	-6.51	-6.53	-6.50	-6.50	-6.50	-
Cavan County	-6.48	-6.50	-	-	-	-6.50
Clare County	-6.48	-6.50	-	-	-	-

Irish counties clustering

Coefficients of Irish counties from the standard GLM to coefficients after clustering:



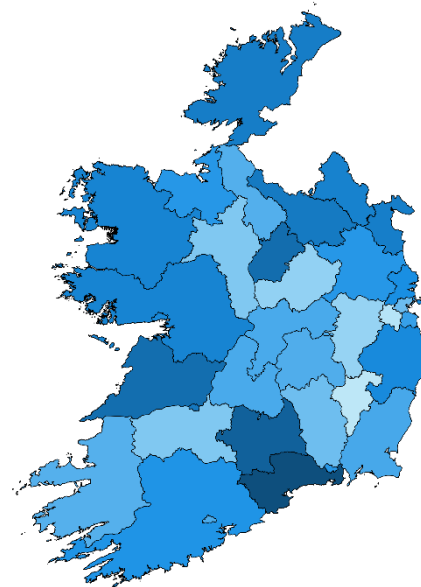
Frequency: before clustering



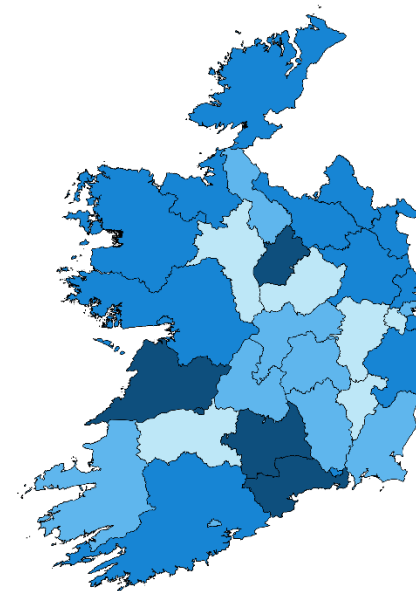
Frequency: after clustering

Irish counties clustering

Coefficients of Irish counties from the standard GLM to coefficients after clustering:



Severity: before clustering



Severity: after clustering

FC-BMA results of Sweden data set

Prediction comparison (80% training data, 20% testing data) using Gini index and root mean squared error (RMSE).

		Gini index	RMSE
Frequency	No-FC	0.8266	16.3
	FC-only	0.8267	15.0
	FC-BMA	0.8267	21.4
Severity	No-FC	0.0567	3840.4
	FC-only	0.0576	3829.4
	FC-BMA	0.0576	3829.7

FC-BMA results of Irish insurer data set

Prediction comparison (80% training data, 20% testing data) using Gini index and root mean squared error (RMSE).

		Gini index	RMSE
Frequency	No-FC	0.7000	0.143
	FC-only	0.7016	0.140
	FC-BMA	0.7019	0.138
Severity	No-FC	0.5565	4017.6
	FC-only	0.5745	2108.5
	FC-BMA	0.5747	2108.0

Summary

- FC-BMA deals with model selection and uncertainty and categorical level selection simultaneously.
- It helps improve model parsimony, interpretability and predictive quality.
- Compared with other existing methods in the literature, it does not require determination of extra parameters.
- Contrasts with the commonly used CART from machine learning.
- It can be a challenge to obtain the optimum through stochastic optimization and possibly could take a while to converge to the optimum solution.

What's next? – ongoing work

Claims from multiple risk categories can be correlated, even though in many cases different categories are modelled and predicted independently

- Within one product line (e.g. accidental damage and property damage)
- Across product lines (e.g. motor insurance and home insurance)

		Observed data			
		PD			
		0	1	2	3
AD	0	391552	2184	24	0
	1	6428	2031	19	1
	2	95	45	11	0
	3	6	1	0	0

		Assuming independence, expected data			
		PD			
		0	1	2	3
AD	0	389537	4170	53	1
	1	8388	90	1	0
	2	149	2	0	0
	3	7	0	0	0

What's next? – ongoing work

Claims from multiple risk categories can be correlated, even though in many cases different categories are modelled and predicted independently

- Within one product line (e.g. accidental damage and property damage)
- Across product lines (e.g. motor insurance and home insurance)

Multivariate Poisson and Gamma regression to the rescue!

		Observed - Expected			
		PD			
		0	1	2	3
AD	0	2015	-1986	-29	-1
	1	-1960	1941	18	1
	2	-54	43	11	0
	3	-1	1	0	0

References:

- Faraway, J. (2016). faraway: Function and datasets for books by Julian Faraway. R package version 1.0.7.
- Gertheiss, J. and Tutz, G. (2010). Sparse modelling of categorical explanatory variables. pages 2150-2180.
- Hoeting, J. A., Madigan, D., Raftery, A. E., and Volinsky, C. T. (1999). Bayesian Model Averaging: A Tutorial. *Statistical Science*, 14(4):382-417.
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- Hu, S., O'Hagan, A. and Murphy, T.B. (2018). Motor Insurance Claim Modeling with Factor Collapsing and Bayesian Model Averaging. *Stat*, 7(1).
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- Ohlsson, E. (2008). Combining generalized linear models and credibility models in practice. *Scandinavian Actuarial Journal*, 2008(4):301-314.
- Raftery, A., Hoeting, J., Volinsky, C., Painter, I., and Yeung, K. Y. (2015). BMA: Bayesian Model Averaging. R package version 3.18.6.

Questions?

Comments?

**Thank you for
listening.**

Empowering Citizens. Smarter Societies.

Thank You

SAI pricing seminar

Mr Sen Hu, Dr Adrian O'Hagan, Prof T. Brendan Murphy

A World Leading SFI Research Centre

Break Out Session

Commercial Lines
Pricing Techniques



Eoin O'Baoighill



Current Hot Topics
Personal Lines Pricing



Jennifer Quigley





Society of Actuaries in Ireland

Commercial Lines Pricing Techniques

Eoin Ó Baoighill
21 March 2018

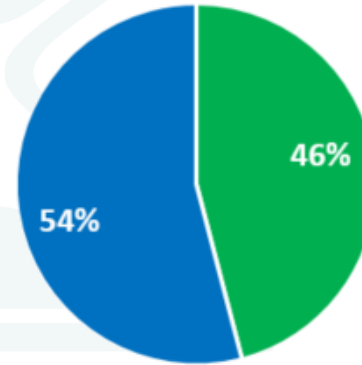
Disclaimer

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Differences from Personal Lines

- Smaller volumes of data
- Historic data collection
- Heterogeneous risks
- Complex covers
- Underwriter judgment
- Prone to large losses

GWP Split



■ Commercial ■ Personal

Underwriter vs Actuary

- Never have enough data to model everything
- Expert judgement required for all models
- Actuaries bring different dimension to the pricing
- Policy wording often not understood
- Actuarial resources are scarce

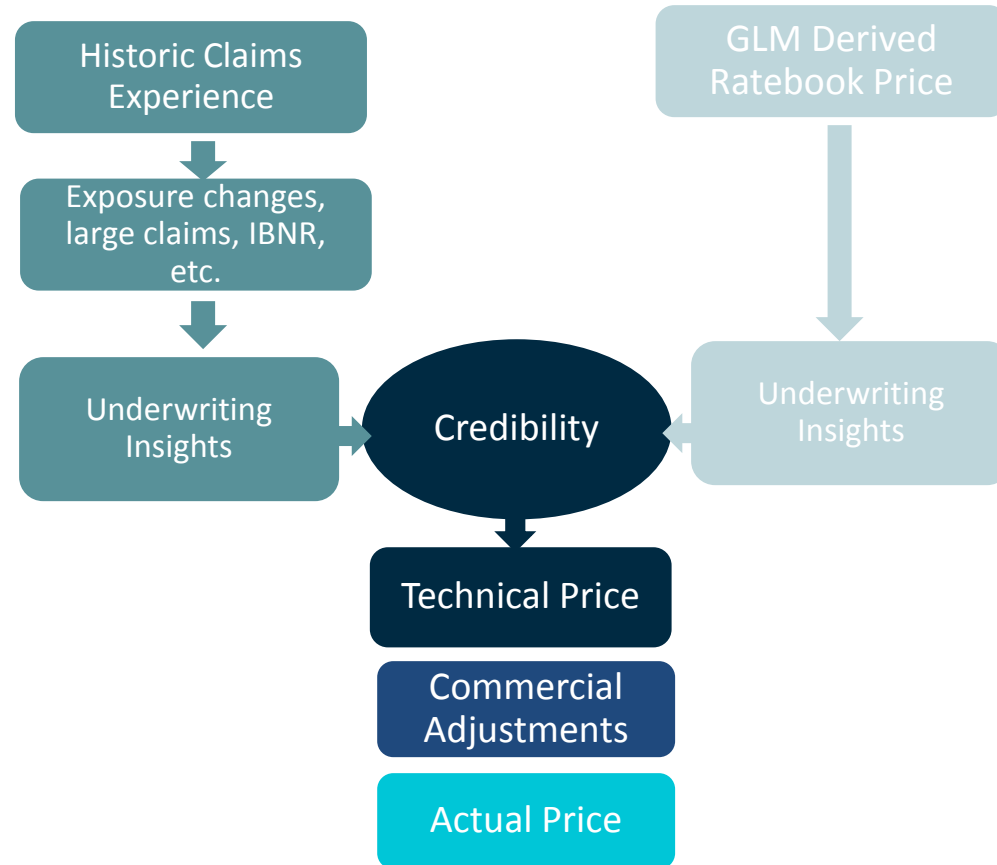


Standard Methodologies

- Fleet
- SME Package Insurance
- Employers Liability and Public Liability
- Property



Fleet



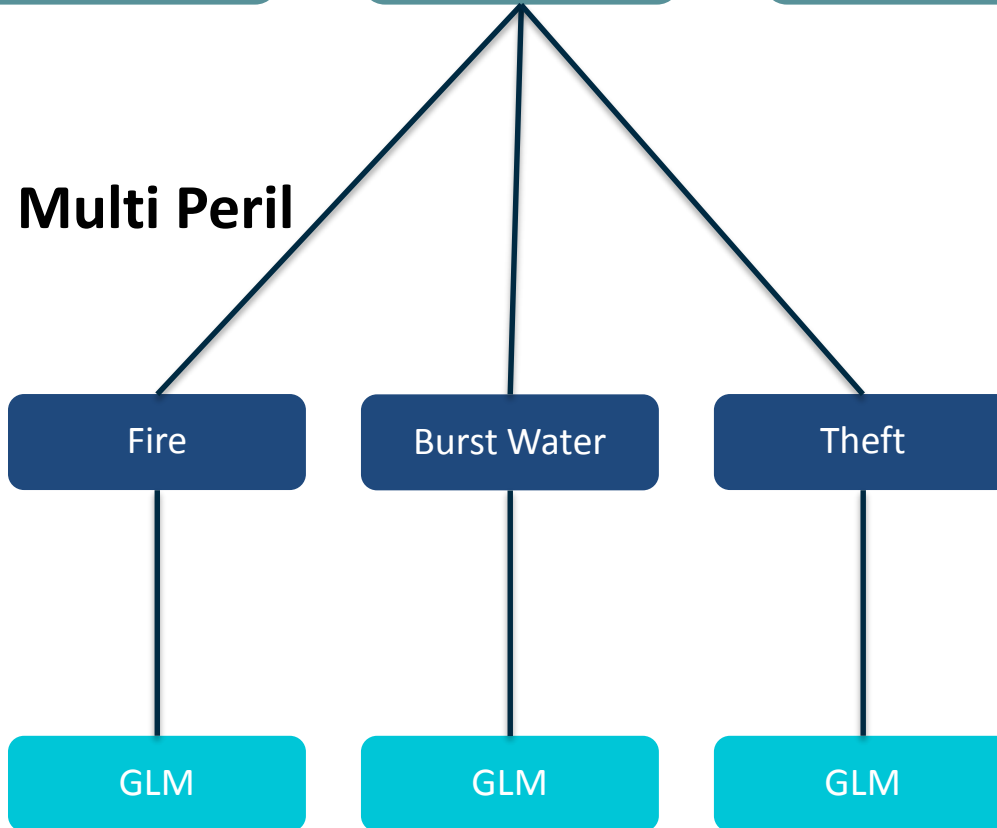


SME Multi Peril

Additive Structure



Multi Peril





Liability

Employers' Liability, Public Liability, Products Liability





Liability

- Exposure measured by turnover (PL) or wageroll (EL)
- GLMs possible – lack of data in Ireland
- Credibility approach used for larger risks
- Monte Carlo Simulation for high excesses and aggregate deductible policies



Commercial Property





Commercial Property

What can actuaries do?

- Pool data
- Rate change monitoring
- Long term portfolio view
- Weather modelling
- Trade isn't best measure of risk – work with underwriters to find better measures



New Technologies - Innovation Units

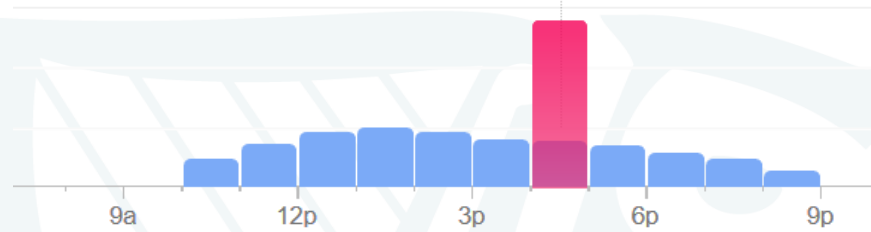
 Global Innovation Center	 Innovation Unit	 Digital Ventures	 Groupama Lab	 Munich RE	 SOMPO Sompo Digital Lab
 Innovation Office	 White Collar Factory	 Ergo Digital Ventures	 Firemark Labs	 MS Amlin Edge	 State Auto Labs Corp.
 Asia Lab	 Fulfilling the Promise Since 1876	 EHDA	 intact lab	 Nationwide REFINERY	 The Camp
 Innovation Studio	 Innovation Lab	 FAIR Ventures	 John Hancock LOF	 NN SPARKLAB Powered by NN Non-Life	 USAA USAA Labs
 Digital Garage	 CUNA MUTUAL GROUP	 FARMERS INSURANCE	 SOLARIA labs A LIBERTY MUTUAL ENDEAVOR	 BIG	 WINDHAVEN INSURANCE ClutchAnalytics
 Kamet Data Innovation Lab AXA Digital Agency	 Desjardins Lab	 GORE MUTUAL	 LLOYDS BANKING GROUP	 QBE Digital Innovation Lab	 XL CATLIN Accelerate
 Baloise Group	 The Hanover Insurance Group	 GREENLIGHT RE Greenlight Re Innovation	 lumenlab MetLife Innovation Centre	 SCOR SCOR P&C Ventures	

Source: Coverager

New Technologies - Data



👤 Live: Busier than usual



New Technologies – Expenses And Automation

SB Simply
Business

Optisure


attune

Allianz 


bunker.

NEXT
INSURANCE

Summary

- Strong rating platform
- External data feeds
- Regular/Easy updates
- Learn from underwriters
- Incorporate underwriter feedback



Questions?



Institute
and Faculty
of Actuaries



Society of Actuaries in Ireland

PRICES, PRODUCTS AND PROFESSIONALISM – BRINGITON!

SAI Pricing Seminar
Wednesday – 21st March, 2018

- ❖ Aidan Redmond
- ❖ Grainne Murray
- ❖ Jenny Johnston
- ❖ Mark McCormick
- ❖ Shane Walsh

with Neil Hilary as facilitator

Prices, products and professionalism



You cannot lose - A product in four movements

What should the professional actuary do?





Prices, products and professionalism

BRINGTON FINANCIAL SERVICES INSURANCE GROUP

- Grainne (actuary) on GI side, works in pricing and products
- Mark (non-actuary), chief underwriter and Grainne's boss
- Shane prod. development actuary at Life Line, sister company
- Jenny (non-actuary), head of marketing and Shane's boss

NEVERSAYNO REINSURANCE

- Aidan, pricing actuary



Prices, products and professionalism



1. New product for Grainne

- What should she do? Please discuss



Prices, products and professionalism

1. New product for Grainne

- Professionally, this work is outside her competence.
- What knowledge on the new product has been published?
- External consultant or reinsurer can help.
- Obtain product details from competitors.
- Old colleagues, dining clubs (but beware confidentiality).
- Audit trail behind on what she did, and why she did it.
- Ombudsman reports for any regular problems with the product.
- Independent helplines (Prof Support Service)
- TASs, Actuaries' Code, (ASP)
- Pressures from non-actuarial bosses.



Prices, products and professionalism



2. “I want it and I want it now”

- What additional issues arise from the boss’ command that numbers are on his desk by lunchtime? Please discuss



Prices, products and professionalism

2. Lunchtime demand

- Documentation
- Thorough professional job
- External input
- Checking and peer review
- Other workload and priorities
- Pressures from non-actuarial bosses
- What if your boss is an actuary? Does that make a difference?
- Communication: “sighting act” first, more work later
- Guesswork => refuse?





Prices, products and professionalism

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NEVERSAYNO REINSURANCE

- Aidan, pricing actuary



Prices, products and professionalism

3. Colleague's error

- What should Grainne do? Please discuss
- Options:
 - Shane?
 - Your boss (Mark) – this might get political
 - Compliance
 - IFoA/SAI – PSS?
 - IFoA/SAI – discipline?





Prices, products and professionalism

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NEVERSAYNO REINSURANCE (GI)

- Aidan (pricing actuary), long-term contact of Grainne

Prices, products and professionalism

4. Error by outside actuary (in your favour)

- What should Grainne do?





Prices, products and professionalism

4. Error by outside actuary (in your favour)

- It's a commercial decision – Grainne should fill his boots?
- Grainne must ask him if he is happy with his figures first?
- Commercial reasons for her low quote?
- Grainne should report her to IFoA/SAI immediately?
- Go to IFoA/SAI – but **not until** reinsurance treaty signed?
- Will reinsurer meet all claims? Review at renewal?
- Are reinsurer's judgement and practices now in question?
- Whistle-blowing?



Prices, products and professionalism

Reinsurance price confirmed – who gets the profit?

- GI's arbitrage – it stays in the GI company
- It is Life Line's product – profit must be returned here
 - Improve its tight margins
- Further Life Line should cut premiums to customers
 - Treating customers fairly
 - Competitors will do this in time anyway
- The profit has been generated by Neversayno (GI reinsurer).
 - They control its emergence and will ultimately claw it back





Prices, products and professionalism

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with Neil Hilary as facilitator



Society of Actuaries in Ireland

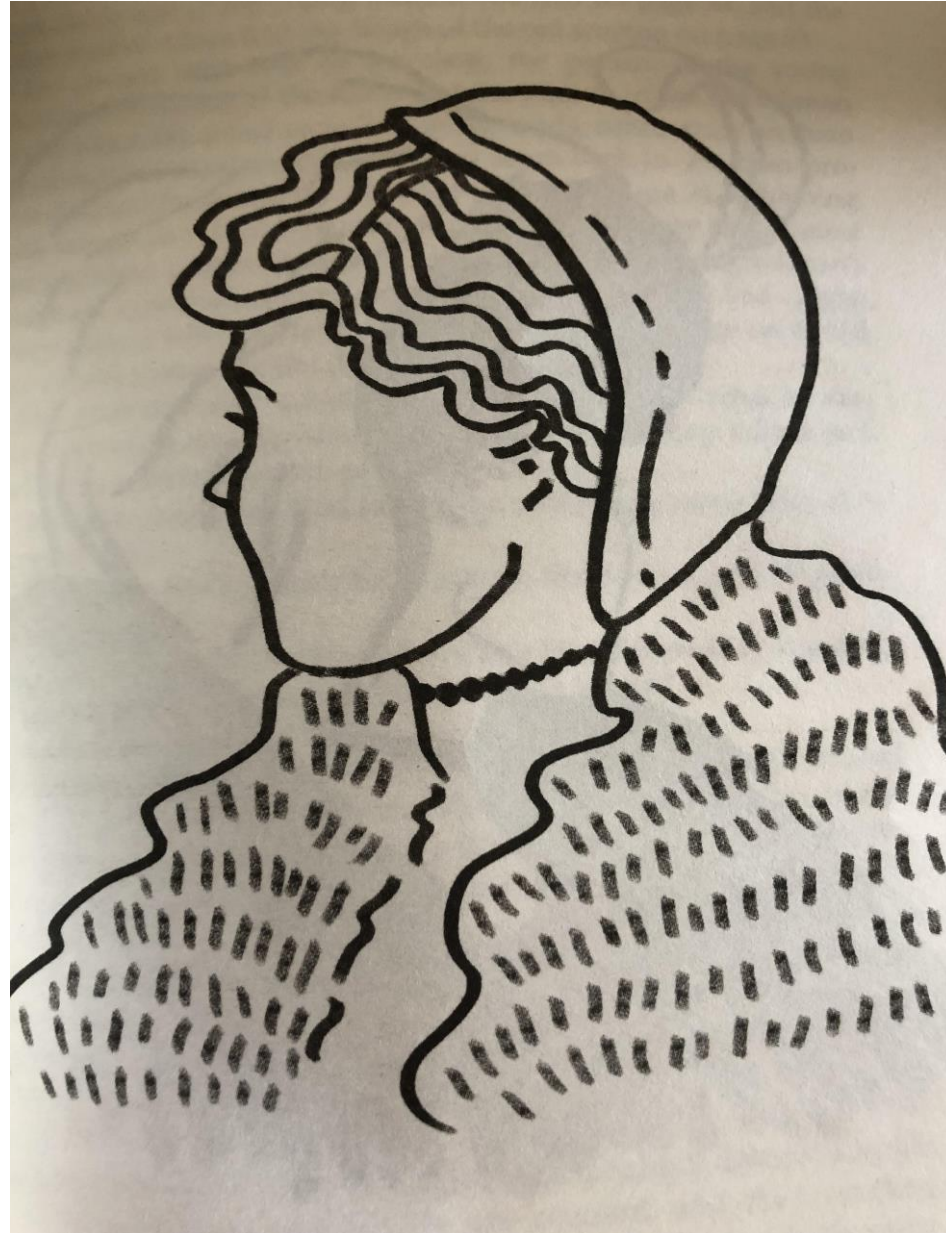
Professionalism
“ambiguous illusions”

Wednesday – 21st March, 2018

Cecilia Cheuk



Young Lady



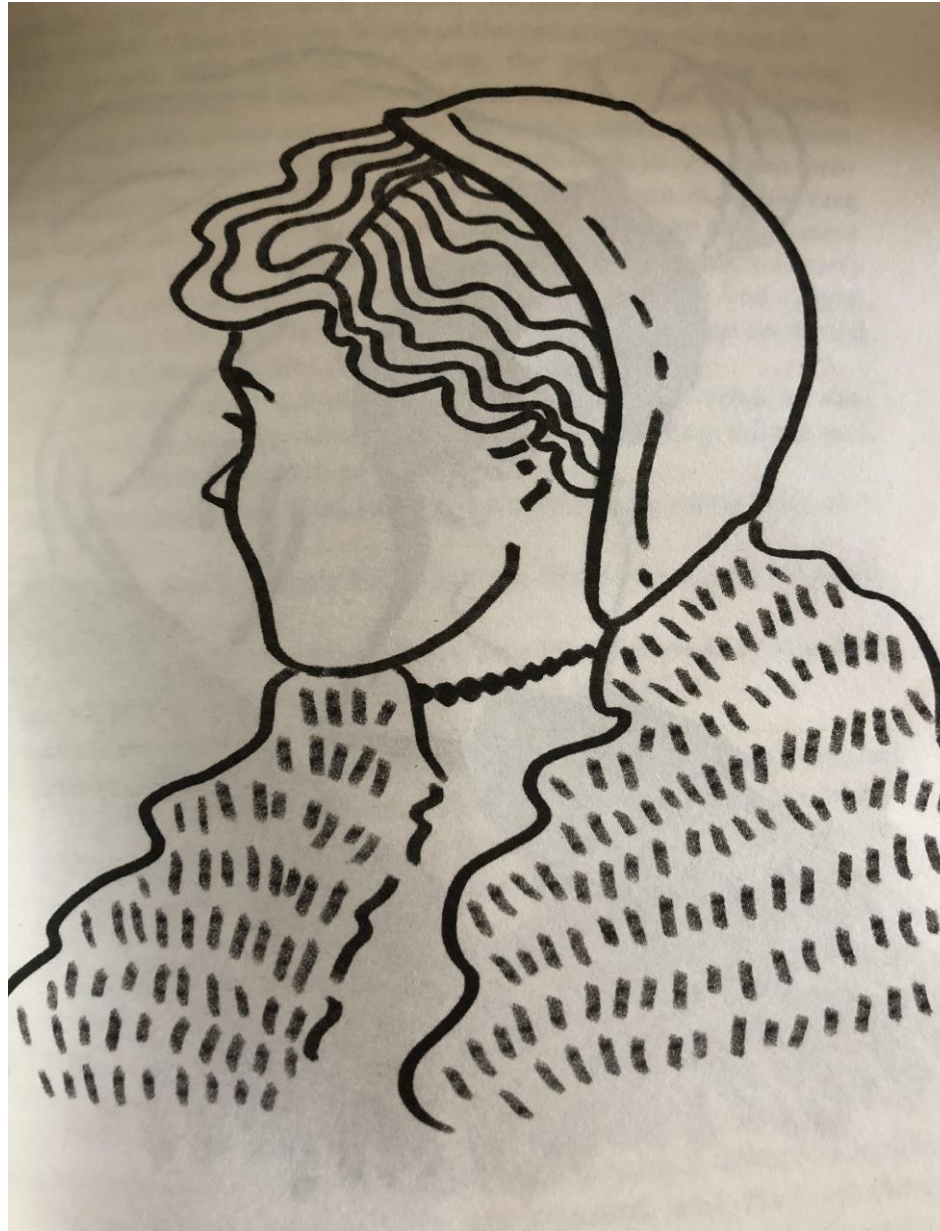


The Boring Figure



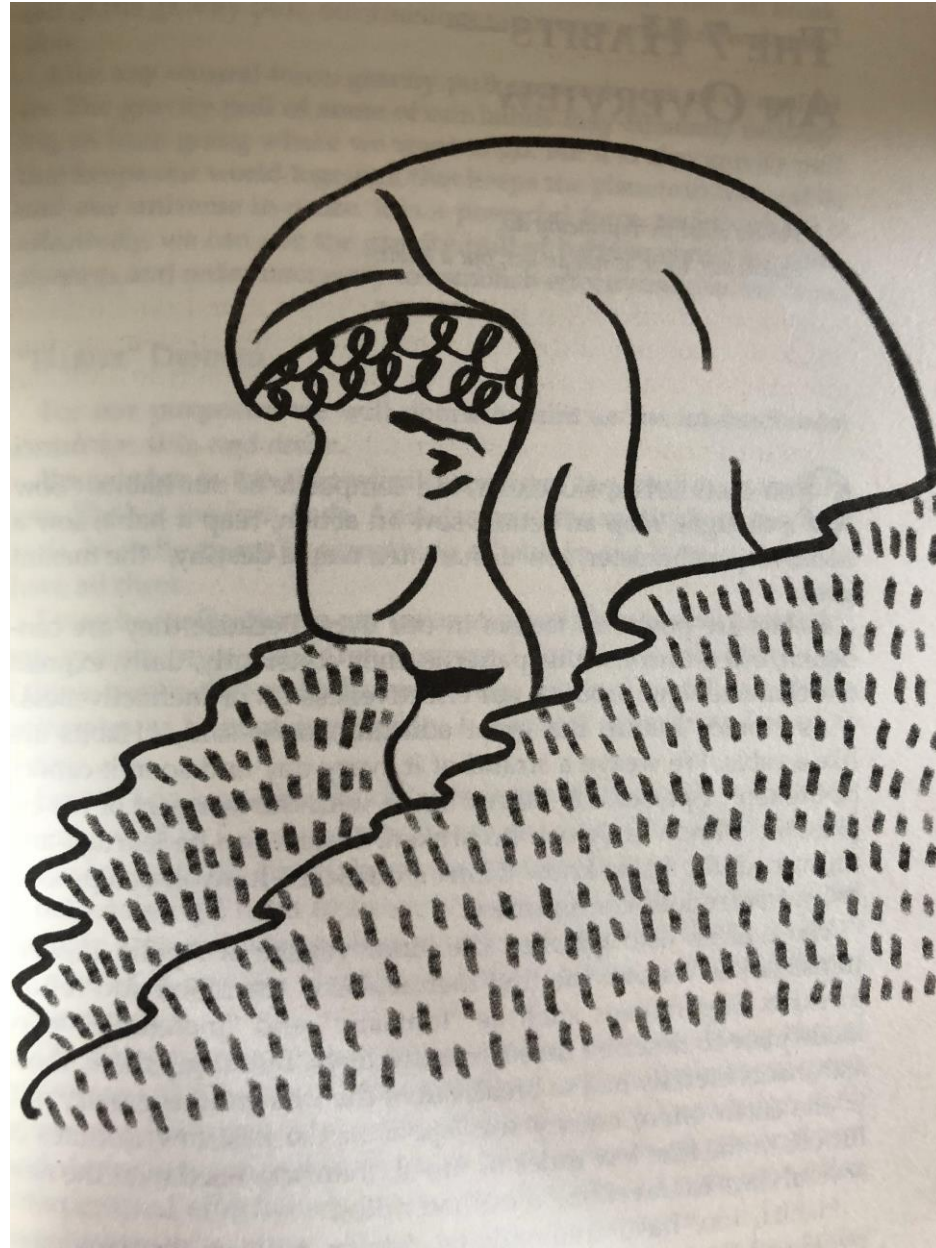


Perception from existing information





Influence from other viewpoint

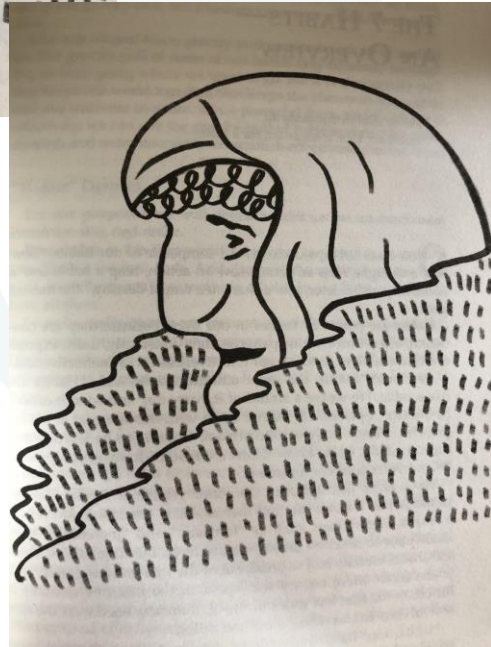
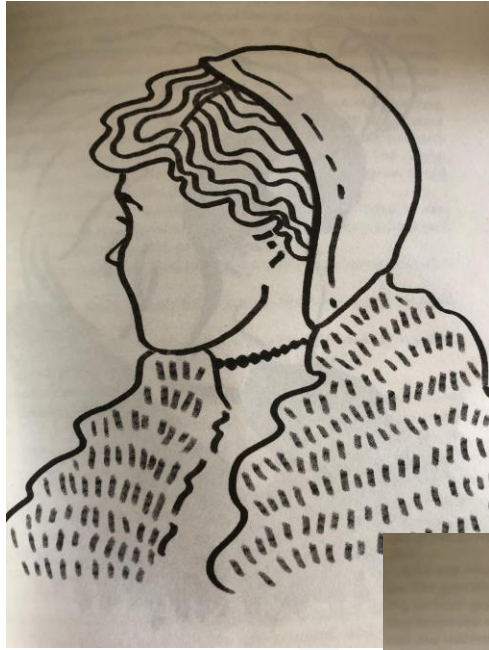




Can you see the old woman now?



Different view point – Young Lady / Old Woman





Important to recognise

- Other people may have very different view based on the same facts, but can be equally valid.
- Prior viewpoint or experience are important, but may also cloud our judgement and confine the possible results that we produce.
- The influence of others can have a strong impact on how we approach things and may affect the outcome of our work leading to very different results or conclusion.



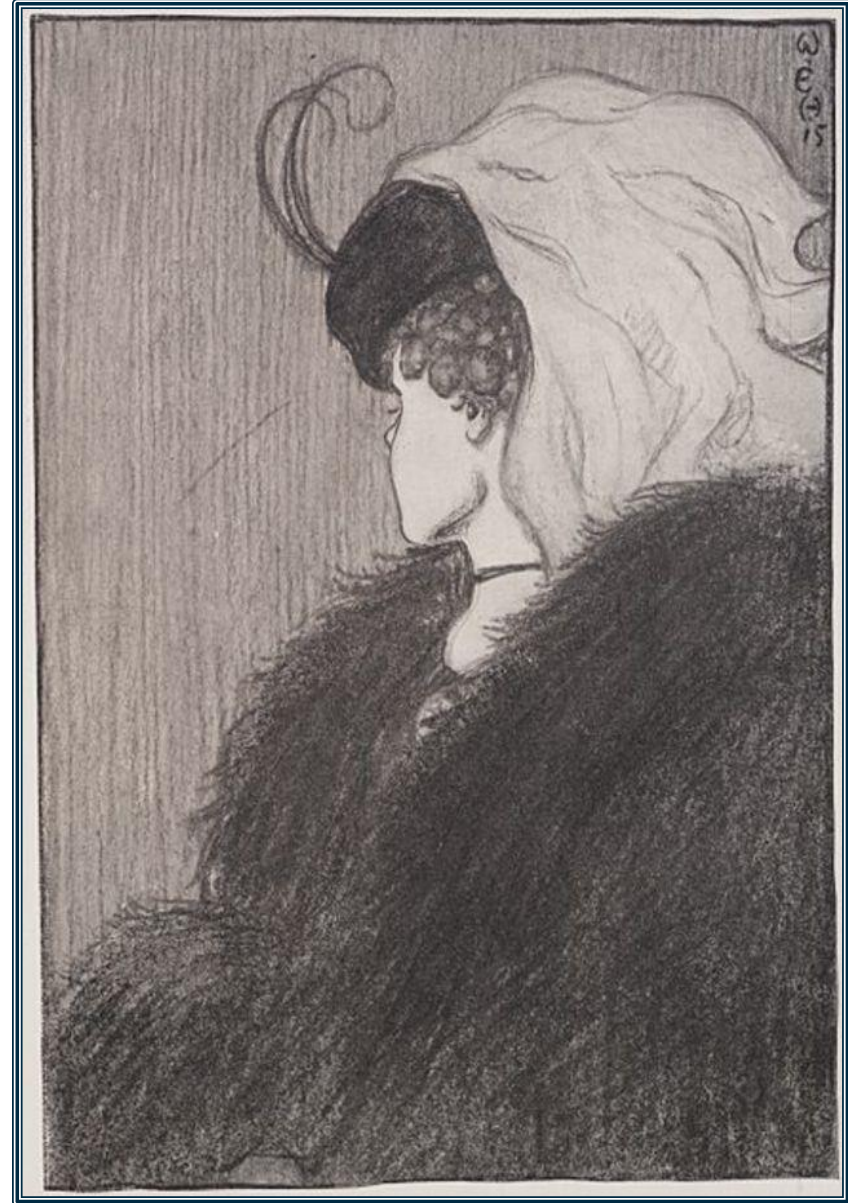


Illusion still exist in colour





Earliest Known Form





Society of Actuaries in Ireland

- **18th May: Annual Convention**
 - **24th May: ERM Practice**
 - **15th June: General Insurance Practice**
-

Professionalism CPD Events



Society of Actuaries in Ireland

Special Presentation

Neil Hilary



Neil Hilary



Institute
and Faculty
of Actuaries

- **Developed Contents** for Professionalism Training for **new qualifiers**.
- Obtained **full accreditation with IFoA** on SAI courses.
- Provided support to deliver **professionalism training for experienced actuaries**.
- **Business Awareness Module** courses in Dublin.
- **Train the Trainer** event for SAI members.
- Presented courses and presentations to SAI members.



IFOA Education Actuary





Society of Actuaries in Ireland

Closing

Agenda – Non-Life Pricing Seminar 2018

Time	Title	Speakers
8:30 – 8:35	Welcome	Cecilia Cheuk
8:35 – 9:20	Machine Learning	Duncan Anderson
9:20 – 10:05	Advanced Modelling Techniques for General Insurance Claims Data	Adrian O’Hagan/Sen Hu
10:05 – 10:25	Coffee Break	
10:30 – 11:15	Parallel Sessions	
	A. Commercial Lines Pricing Techniques	Eoin O’Baiohill
	B. Current hot-topics in Personal Lines Pricing	Jenny Quigley
11:20 – 12:50	Professionalism	
	“YouCanNotLose” <i>(Volunteers: Aidan Redmond, Grainne Murray, Jenny Johnston, Mark McCormick, Shane Walsh)</i>	Neil Hilary
	“ambiguous illusion”	Cecilia Cheuk
12:50 - 13:00	Closing	Cecilia Cheuk

Disclaimer:

The material, content and views in the following presentation are those of the presenter(s).



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Thank You

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