28 November – 1 December 2004

Xth Accident Compensation Seminar 2004

Institute of Actuaries of Australia

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Xth Accident Compensation Seminar

Soft-Computing in Accident Compensation

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Institute of Actuaries of Australia

Outline

- Features of accident compensation data
- Overview of soft-computing methods
- Case study: CTP reserving

Accident Compensation Data

- Features of accident compensation data that make pricing and reserving difficult
  - Changes in the rate of claim finalisation
  - Legislative changes
  - Seasonality
  - Superimposed inflation varying by
    - Experience year
    - Age of claims
- Can be dealt with using GLMs

Example Data

- Data relates to CTP insurance from one state
- Claim file of 60,000 claims from 1994 – 2003
- Features of data illustrated by a GLM model of average size of finalised claim
- Model was developed for pricing and reserving

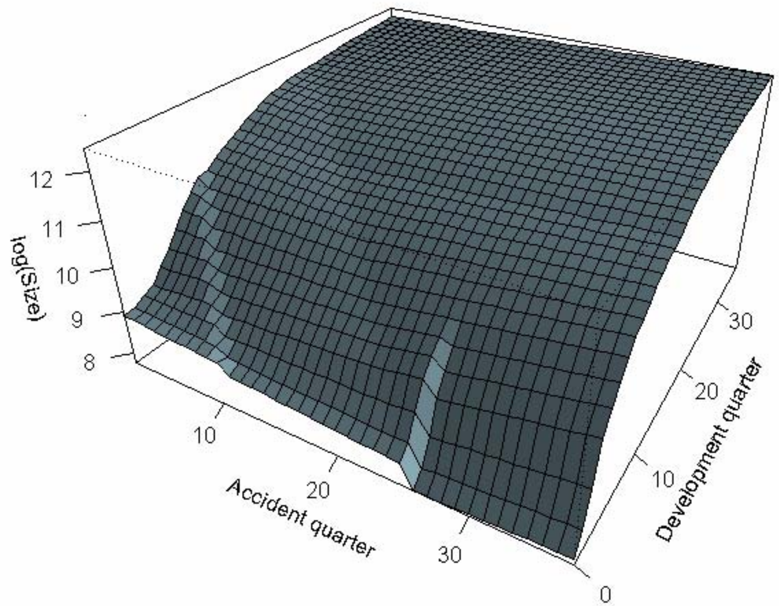
GLM Model

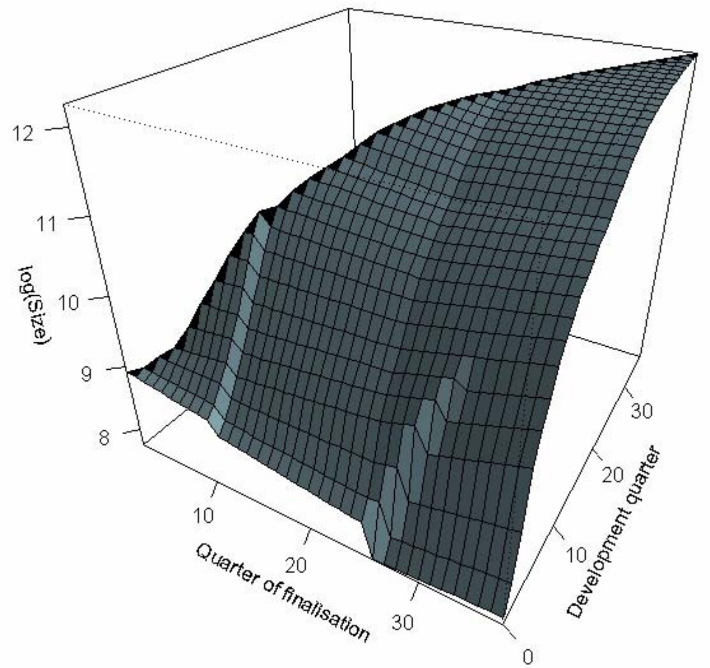
- Model of average size of finalised claims

$$
\begin{aligned}
E[Y_r] = \exp \{a &+ ß^d_1\, t_r + ß^d_2 \max(0,10-t_r) \\
&+ ß^d_3 \max(0,t_r-80) + ß^d_4\, I(t_r < 8) && [\textit{Operational time effect}] \\
&+ ß^s\, I(k_r=\text{March quarter}) && [\textit{Seasonal effect}] \\
&+ ß^f_1\, k_r + ß^f_2 \max(0,k_r - 2000Q3) \\
&+ ß^f_3\, I(k_r<97Q1) && [\textit{Finalisation quarter effect}] \\
&+ k_r\, [ß^{tf}_1\, t_r + ß^{tf}_2 \max(0,10-t_r)] && [\textit{Operational time x finalisation quarter interaction}] \\
&+ \max(0,35-t_r)\, [ß^{ta}_1 + ß^{ta}_2\, I(i_r > 2000Q3)]\} && [\textit{Operational time x accident quarter interaction}]
\end{aligned}
$$

GLM Model

- Plot of log(average claim size) without seasonality





GLM vs Soft-Computing

- Building a GLM model takes time
- Specifying form of model can be difficult
  - Interaction terms can be troublesome
- Quality of model will depend on skill of model builder

- **Question: Are there better ways?**

Soft-Computing

- Collection of methods
  - Designed specifically for large and/or complicated data sets
  - Largely automated
- Uses
  - Data mining
  - Modelling complex "non-linear" features
- Examples
  - Neural Networks, MART, MARS

Case Study – CTP Data

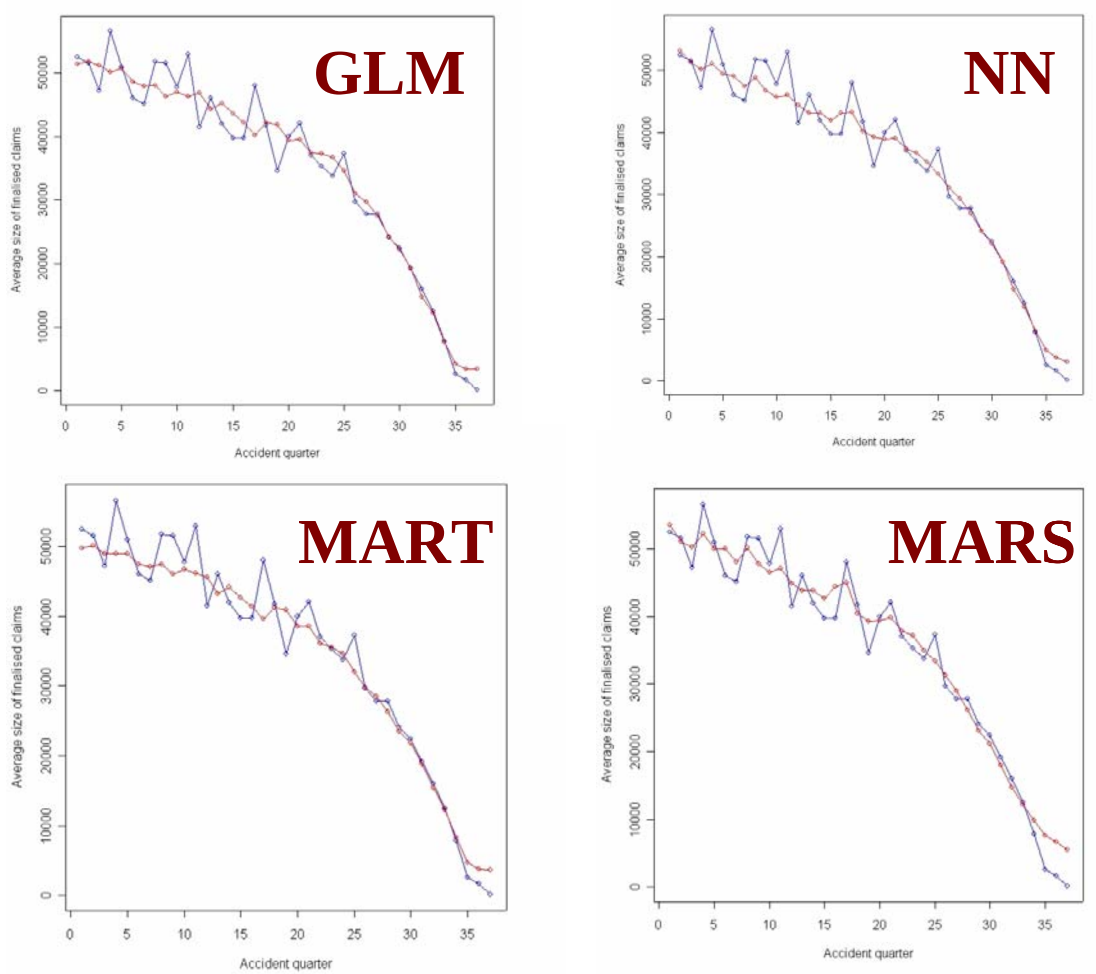
- Aim: Compare models of the average size of finalised claims
  - GLMs
  - Neural Networks
  - MARS
  - MART

Soft-Computing Background

- GLMs
  - Manually build model that matches the data
- Neural Networks
  - Model is so flexible that it can model almost anything
  - Various techniques used to protect against overfitting
- MART and MARS
  - Regression functions built automatically by progressively adding more terms
  - Each term constructed out of simple functions

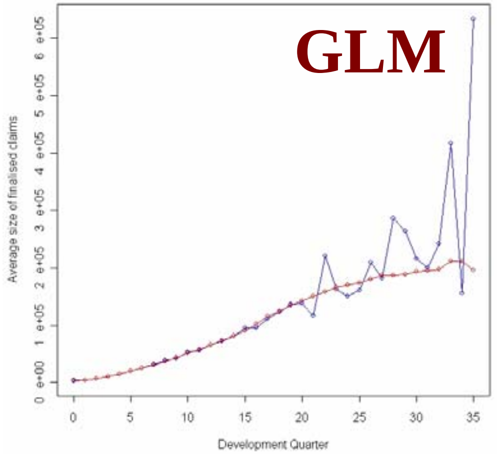
Results: one-way tables

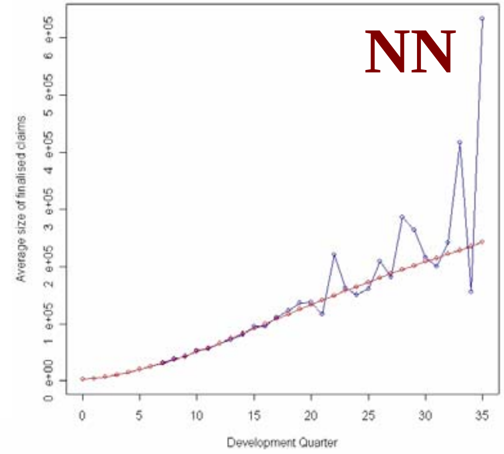
- Finalised claims against accident quarter

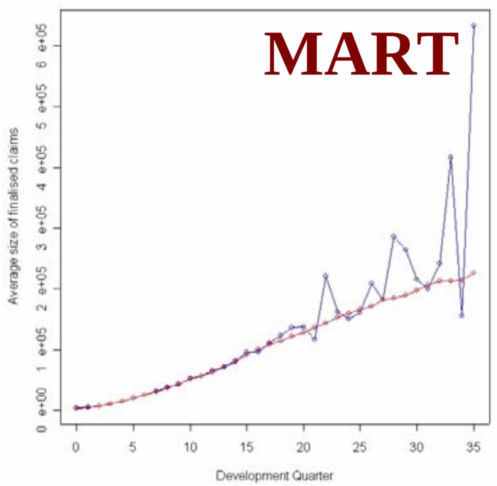


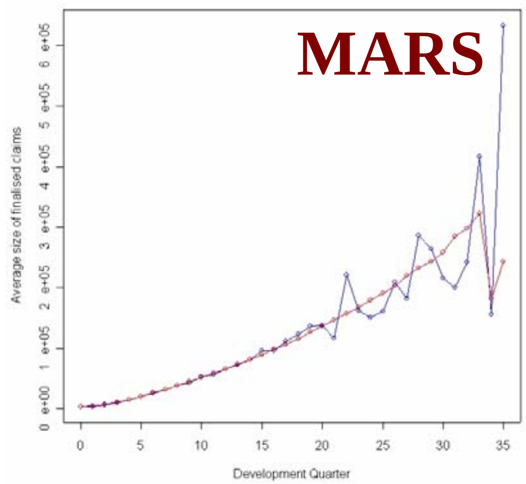
Results: one-way tables

- Finalised claim against development quarter









Triangles of observed to fitted ratios

GLM

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Sep-94	NA	31%	80%	154%	198%	141%	75%	80%	83%	73%	114%	100%	90%	69%	63%	101%	76%	45%
Dec-94	23%	104%	95%	100%	134%	120%	123%	97%	81%	124%	95%	86%	81%	139%	95%	91%	100%	92%
Mar-95	23%	75%	96%	105%	99%	112%	89%	84%	98%	129%	158%	94%	84%	61%	65%	84%	68%	91%
Jun-95	NA	57%	92%	112%	184%	117%	84%	98%	111%	88%	109%	112%	196%	138%	91%	102%	112%	118%
Sep-95	6%	83%	112%	134%	106%	105%	92%	82%	120%	80%	87%	76%	95%	126%	49%	103%	147%	106%
Dec-95	127%	94%	90%	95%	90%	88%	93%	112%	78%	105%	83%	81%	115%	81%	131%	112%	133%	103%
Mar-96	NA	101%	89%	78%	118%	80%	107%	70%	91%	76%	72%	92%	91%	109%	81%	109%	84%	135%
Jun-96	NA	77%	78%	94%	103%	91%	86%	103%	101%	79%	95%	140%	106%	101%	104%	151%	111%	89%
Sep-96	78%	72%	107%	110%	108%	100%	96%	112%	120%	114%	104%	122%	114%	129%	112%	76%	81%	83%
Dec-96	NA	87%	120%	100%	83%	92%	117%	100%	82%	101%	100%	107%	75%	91%	126%	59%	93%	108%
Mar-97	NA	91%	107%	100%	94%	81%	100%	119%	112%	86%	137%	91%	118%	80%	73%	91%	96%	131%
Jun-97	NA	122%	124%	96%	86%	77%	112%	86%	99%	101%	91%	81%	77%	75%	86%	113%	123%	115%
Sep-97	2%	90%	92%	92%	98%	96%	93%	92%	91%	99%	110%	137%	88%	153%	111%	95%	75%	78%
Dec-97	94%	73%	112%	86%	89%	105%	84%	129%	119%	106%	87%	79%	129%	87%	86%	113%	68%	78%
Mar-98	NA	96%	96%	104%	85%	92%	96%	94%	103%	88%	57%	100%	95%	81%	157%	91%	65%	78%
Jun-98	NA	112%	109%	103%	97%	98%	115%	114%	114%	77%	101%	91%	110%	127%	88%	136%	85%	73%
Sep-98	114%	116%	123%	100%	111%	124%	112%	112%	112%	115%	135%	108%	128%	89%	107%	173%	102%	128%
Dec-98	NA	114%	108%	102%	112%	106%	99%	93%	126%	79%	104%	101%	80%	94%	127%	82%	113%	108%
Mar-99	8%	85%	109%	95%	86%	94%	70%	107%	84%	92%	87%	79%	72%	88%	79%	82%	68%	61%
Jun-99	5%	95%	93%	96%	91%	99%	110%	111%	113%	120%	103%	82%	84%	80%	152%	104%	73%	113%
Sep-99	4%	90%	110%	97%	92%	111%	114%	103%	128%	99%	134%	93%	98%	104%	108%	130%	80%	
Dec-99	12%	124%	104%	90%	111%	92%	108%	109%	97%	113%	103%	93%	97%	75%	100%	97%		
Mar-00	112%	98%	86%	115%	86%	106%	93%	88%	93%	92%	94%	85%	143%	72%	80%			
Jun-00	63%	92%	92%	82%	84%	91%	95%	95%	91%	85%	108%	104%	77%	90%				
Sep-00	NA	138%	99%	81%	86%	114%	106%	120%	105%	94%	169%	98%	84%					
Dec-00	8%	108%	103%	100%	84%	98%	91%	86%	86%	99%	101%	113%						
Mar-01	29%	85%	106%	112%	85%	101%	104%	110%	98%	76%	80%							
Jun-01	43%	98%	96%	76%	103%	97%	111%	110%	109%	85%								
Sep-01	42%	106%	94%	107%	132%	114%	87%	98%	79%									
Dec-01	45%	89%	93%	108%	118%	103%	114%	73%										
Mar-02	54%	72%	107%	116%	98%	110%	81%											
Jun-02	33%	102%	133%	113%	102%	110%												
Sep-02	110%	88%	92%	107%	102%													
Dec-02	251%	96%	110%	100%														
Mar-03	37%	73%	55%															
Jun-03	70%	46%																
Sep-03	3%																	

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Sep-94	113%	231%	109%	154%	76%	81%	63%	51%	448%	5%	188%	154%	77%	NA	106%	NA	3%	324%
Dec-94	113%	90%	56%	99%	58%	94%	105%	202%	46%	56%	47%	81%	101%	145%	280%	298%	78%	NA
Mar-95	103%	103%	66%	48%	68%	40%	108%	89%	253%	52%	46%	50%	192%	139%	160%	279%	77%	
Jun-95	80%	86%	84%	67%	268%	222%	73%	257%	62%	98%	75%	196%	91%	172%	112%	90%		
Sep-95	142%	83%	50%	96%	45%	92%	115%	51%	54%	42%	668%	61%	140%	38%	20%			
Dec-95	110%	90%	70%	63%	94%	66%	62%	141%	58%	31%	54%	66%	63%	29%				
Mar-96	68%	180%	43%	56%	58%	60%	70%	74%	79%	119%	54%	482%	38%					
Jun-96	84%	68%	273%	66%	65%	197%	110%	122%	85%	76%	64%	103%						
Sep-96	104%	107%	202%	68%	103%	136%	130%	80%	179%	178%	232%							
Dec-96	191%	69%	80%	141%	258%	57%	50%	65%	208%	181%								
Mar-97	146%	103%	133%	57%	426%	110%	107%	38%	153%									
Jun-97	63%	81%	98%	76%	118%	34%	71%	51%										
Sep-97	57%	85%	103%	83%	420%	102%	116%											
Dec-97	96%	61%	131%	42%	76%	43%												
Mar-98	84%	137%	111%	65%	44%													
Jun-98	87%	52%	39%	67%														
Sep-98	128%	180%	71%															
Dec-98	82%	90%																
Mar-99	80%																	

NN

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Sep-94	NA	34%	59%	112%	155%	125%	76%	76%	84%	91%	121%	102%	91%	74%	61%	95%	72%	46%
Dec-94	38%	93%	81%	85%	118%	118%	117%	97%	95%	129%	95%	85%	86%	137%	93%	92%	107%	93%
Mar-95	28%	85%	102%	98%	94%	102%	86%	94%	100%	127%	156%	99%	83%	60%	64%	86%	69%	94%
Jun-95	NA	84%	105%	105%	160%	109%	89%	98%	108%	87%	115%	110%	188%	133%	89%	91%	101%	117%
Sep-95	18%	123%	114%	122%	102%	110%	91%	80%	118%	84%	88%	76%	96%	132%	47%	100%	155%	120%
Dec-95	336%	112%	87%	98%	94%	85%	88%	108%	80%	107%	84%	82%	119%	77%	120%	110%	138%	102%
Mar-96	NA	132%	107%	89%	116%	78%	104%	71%	95%	79%	74%	96%	88%	103%	78%	109%	83%	134%
Jun-96	NA	123%	100%	94%	99%	89%	85%	106%	104%	79%	97%	133%	98%	96%	99%	137%	103%	87%
Sep-96	251%	105%	106%	106%	106%	99%	99%	116%	122%	116%	101%	114%	109%	124%	102%	72%	82%	89%
Dec-96	NA	90%	115%	102%	83%	96%	124%	103%	85%	102%	99%	108%	76%	86%	121%	63%	102%	115%
Mar-97	NA	94%	100%	97%	99%	85%	100%	120%	113%	86%	139%	91%	111%	72%	70%	91%	91%	125%
Jun-97	NA	135%	116%	103%	93%	79%	112%	89%	104%	107%	94%	79%	74%	79%	95%	120%	128%	130%
Sep-97	3%	89%	89%	97%	101%	94%	94%	95%	94%	101%	109%	132%	89%	155%	109%	94%	76%	85%
Dec-97	134%	67%	110%	91%	88%	108%	89%	135%	120%	106%	86%	81%	130%	83%	81%	116%	75%	84%
Mar-98	NA	86%	93%	106%	90%	99%	99%	92%	103%	89%	60%	103%	92%	77%	156%	96%	68%	84%
Jun-98	NA	101%	99%	110%	104%	99%	107%	110%	111%	77%	96%	81%	99%	117%	81%	118%	82%	77%
Sep-98	149%	98%	105%	103%	113%	115%	106%	109%	110%	106%	119%	96%	117%	80%	90%	148%	93%	125%
Dec-98	NA	96%	89%	105%	107%	103%	101%	99%	128%	79%	105%	107%	83%	93%	132%	93%	133%	119%
Mar-99	9%	77%	106%	95%	87%	95%	74%	105%	84%	94%	93%	82%	71%	93%	94%	101%	78%	74%
Jun-99	7%	83%	92%	107%	95%	97%	100%	107%	112%	124%	102%	78%	84%	83%	156%	104%	79%	129%
Sep-99	5%	81%	114%	108%	93%	99%	106%	99%	129%	95%	128%	94%	105%	110%	108%	142%	94%	
Dec-99	15%	126%	117%	100%	104%	90%	104%	110%	92%	108%	104%	100%	100%	71%	101%	105%		
Mar-00	155%	116%	92%	124%	95%	107%	94%	82%	88%	93%	102%	88%	138%	75%	88%			
Jun-00	142%	98%	99%	107%	94%	96%	88%	93%	94%	97%	115%	104%	83%	100%				
Sep-00	NA	157%	125%	101%	103%	110%	104%	120%	115%	96%	164%	103%	91%					
Dec-00	9%	98%	77%	85%	71%	91%	88%	91%	85%	97%	106%	124%						
Mar-01	43%	93%	84%	96%	83%	92%	109%	106%	98%	81%	90%							
Jun-01	181%	104%	80%	82%	95%	95%	106%	111%	114%	97%								
Sep-01	102%	100%	98%	106%	130%	101%	89%	100%	90%									
Dec-01	71%	121%	87%	112%	106%	103%	111%	82%										
Mar-02	126%	96%	107%	110%	102%	102%	90%											
Jun-02	177%	126%	110%	129%	98%	112%												
Sep-02	279%	75%	95%	107%	108%													
Dec-02	272%	104%	90%	99%														
Mar-03	50%	66%	45%															
Jun-03	95%	40%																
Sep-03	3%																	

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Sep-94	107%	214%	102%	149%	70%	75%	58%	50%	398%	5%	162%	143%	67%	NA	91%	NA	3%	260%
Dec-94	117%	97%	63%	103%	58%	97%	108%	194%	45%	55%	46%	73%	89%	128%	247%	268%	70%	NA
Mar-95	116%	121%	74%	50%	73%	43%	104%	83%	248%	52%	43%	45%	175%	126%	135%	257%	71%	
Jun-95	87%	89%	87%	69%	284%	224%	71%	248%	60%	93%	71%	184%	86%	150%	102%	85%		
Sep-95	154%	86%	54%	106%	47%	93%	116%	54%	55%	41%	649%	59%	137%	37%	19%			
Dec-95	106%	92%	73%	64%	91%	64%	64%	134%	55%	31%	54%	61%	58%	26%				
Mar-96	72%	198%	43%	57%	58%	64%	69%	71%	80%	125%	52%	457%	36%					
Jun-96	89%	66%	267%	64%	68%	194%	110%	122%	89%	75%	63%	101%						
Sep-96	104%	109%	208%	72%	103%	139%	136%	83%	169%	178%	233%							
Dec-96	191%	74%	89%	148%	275%	63%	55%	68%	219%	190%								
Mar-97	145%	108%	135%	60%	462%	125%	110%	38%	167%									
Jun-97	73%	87%	110%	87%	141%	37%	80%	58%										
Sep-97	58%	92%	119%	96%	431%	112%	126%											
Dec-97	109%	71%	160%	46%	88%	49%												
Mar-98	93%	161%	119%	72%	50%													
Jun-98	97%	55%	42%	76%														
Sep-98	119%	179%	73%															
Dec-98	94%	107%																
Mar-99	99%																	

Triangles of observed to fitted ratios

MART

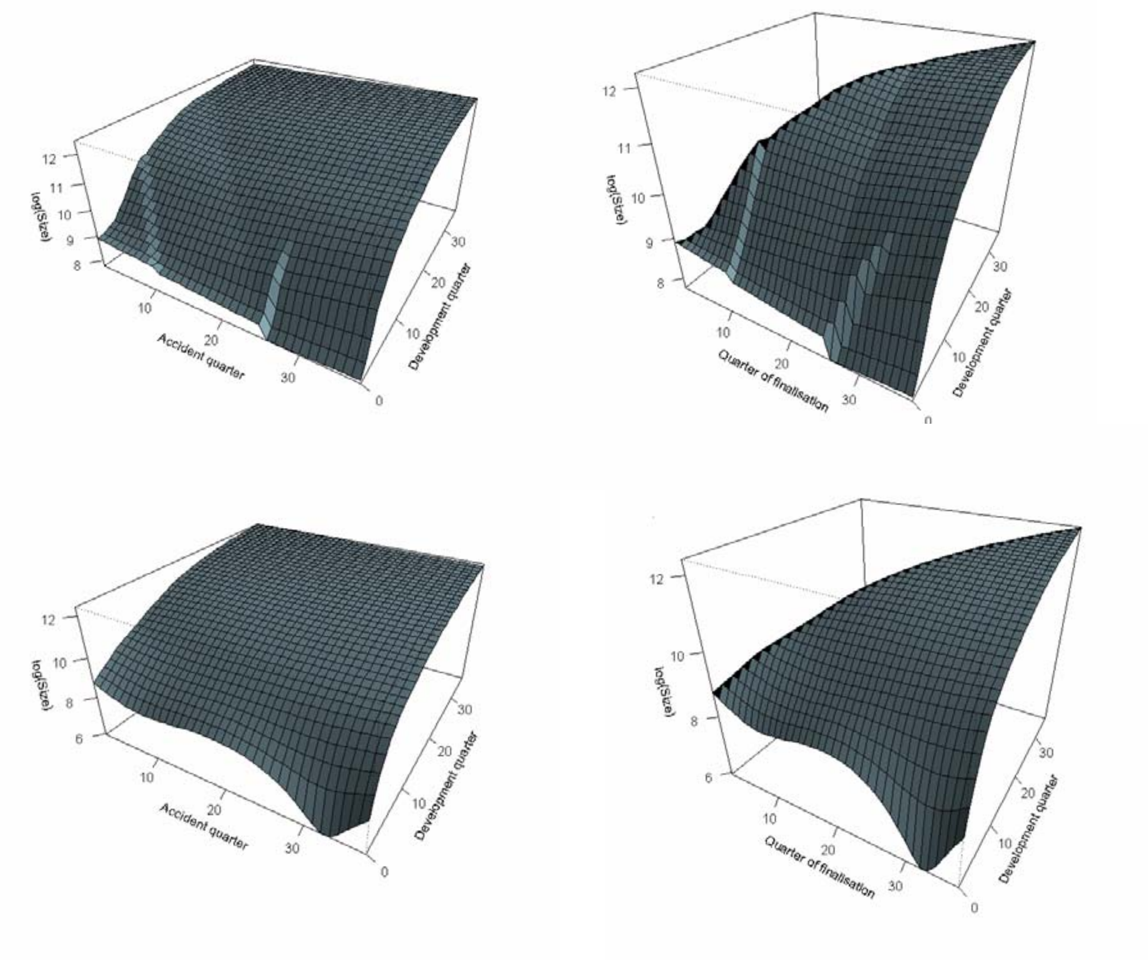
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Sep-94	NA	36%	87%	143%	172%	133%	71%	82%	87%	84%	111%	104%	94%	75%	66%	114%	81%	44%	114%	242%	114%	170%	78%	90%	65%	52%	401%	5%	178%	157%	74%	NA	90%	NA	3%	280%
Dec-94	27%	120%	102%	95%	118%	113%	124%	102%	87%	118%	96%	88%	84%	143%	107%	97%	98%	94%	123%	102%	62%	103%	64%	97%	107%	185%	47%	54%	48%	78%	104%	123%	251%	276%	78%	NA
Mar-95	29%	91%	107%	98%	90%	112%	91%	91%	89%	127%	162%	97%	85%	66%	75%	89%	66%	97%	118%	115%	70%	53%	70%	41%	104%	92%	259%	57%	48%	55%	173%	131%	143%	294%	77%	
Jun-95	NA	70%	101%	107%	171%	112%	89%	90%	104%	90%	110%	113%	202%	147%	100%	107%	112%	121%	85%	90%	93%	71%	279%	212%	76%	261%	65%	99%	83%	176%	86%	154%	113%	90%		
Sep-95	8%	100%	130%	146%	104%	109%	83%	77%	116%	83%	86%	78%	101%	140%	51%	103%	152%	112%	150%	89%	53%	105%	44%	99%	121%	57%	58%	48%	616%	59%	141%	41%	20%			
Dec-95	159%	117%	110%	108%	93%	79%	88%	107%	75%	105%	87%	83%	121%	86%	140%	112%	132%	101%	116%	94%	73%	64%	104%	71%	68%	143%	64%	31%	57%	65%	67%	29%				
Mar-96	NA	122%	106%	85%	103%	75%	104%	66%	90%	78%	75%	93%	92%	121%	83%	105%	81%	138%	72%	188%	43%	62%	62%	66%	71%	81%	80%	124%	53%	511%	38%					
Jun-96	NA	95%	96%	86%	91%	88%	84%	96%	102%	81%	97%	135%	109%	108%	106%	139%	107%	86%	87%	70%	289%	70%	73%	203%	120%	130%	91%	75%	68%	104%						
Sep-96	96%	93%	114%	107%	98%	95%	91%	107%	124%	115%	102%	120%	116%	137%	107%	70%	78%	82%	106%	113%	214%	74%	107%	151%	139%	87%	183%	190%	233%							
Dec-96	NA	96%	126%	99%	76%	87%	113%	98%	84%	98%	100%	109%	79%	88%	118%	57%	89%	110%	203%	73%	88%	147%	286%	61%	55%	64%	220%	183%								
Mar-97	NA	97%	119%	101%	88%	78%	98%	114%	111%	86%	135%	91%	118%	80%	68%	81%	90%	129%	149%	111%	136%	65%	461%	120%	110%	42%	154%									
Jun-97	NA	133%	130%	93%	83%	77%	106%	84%	99%	102%	92%	79%	79%	71%	80%	110%	128%	131%	72%	88%	119%	87%	136%	37%	79%	54%										
Sep-97	2%	93%	98%	90%	97%	93%	87%	90%	91%	98%	107%	138%	91%	148%	98%	91%	75%	84%	63%	99%	120%	99%	468%	120%	133%											
Dec-97	96%	77%	118%	87%	86%	101%	80%	130%	117%	100%	86%	80%	131%	82%	82%	106%	71%	85%	111%	70%	158%	46%	90%	50%												
Mar-98	NA	96%	104%	103%	83%	91%	92%	94%	98%	86%	56%	100%	99%	79%	157%	87%	66%	87%	97%	158%	123%	80%	51%													
Jun-98	NA	115%	110%	105%	96%	98%	111%	109%	113%	76%	94%	87%	108%	132%	95%	134%	83%	77%	97%	57%	46%	80%														
Sep-98	116%	106%	123%	105%	111%	126%	109%	108%	114%	108%	129%	105%	128%	93%	112%	181%	102%	124%	130%	201%	84%															
Dec-98	NA	105%	105%	109%	113%	103%	97%	91%	121%	72%	105%	102%	86%	93%	121%	84%	119%	119%	96%	106%																
Mar-99	8%	76%	115%	97%	87%	92%	70%	102%	80%	93%	86%	83%	75%	87%	79%	86%	74%	71%	94%																	
Jun-99	4%	86%	97%	98%	94%	100%	101%	108%	113%	122%	106%	83%	90%	86%	154%	96%	77%	126%																		
Sep-99	4%	80%	112%	104%	99%	106%	109%	101%	132%	104%	133%	97%	107%	106%	104%	131%	87%																			
Dec-99	10%	112%	109%	101%	110%	89%	111%	112%	104%	114%	107%	98%	102%	79%	104%	95%																				
Mar-00	98%	89%	91%	128%	90%	110%	101%	93%	98%	96%	97%	88%	148%	78%	84%																					
Jun-00	53%	79%	97%	98%	95%	101%	103%	97%	97%	90%	109%	106%	85%	95%																						
Sep-00	NA	118%	105%	99%	108%	131%	118%	126%	113%	96%	169%	105%	93%																							
Dec-00	5%	69%	73%	88%	81%	97%	100%	89%	89%	100%	109%	123%																								
Mar-01	18%	54%	80%	105%	84%	103%	114%	110%	103%	82%	87%																									
Jun-01	27%	69%	78%	78%	101%	98%	115%	111%	120%	94%																										
Sep-01	28%	72%	78%	104%	125%	109%	92%	105%	92%																											
Dec-01	29%	61%	70%	98%	104%	98%	127%	81%																												
Mar-02	38%	49%	86%	102%	89%	115%	98%																													
Jun-02	21%	70%	91%	100%	100%	117%																														
Sep-02	79%	58%	71%	109%	111%																															
Dec-02	171%	69%	86%	102%																																
Mar-03	33%	63%	50%																																	
Jun-03	60%	42%																																		
Sep-03	3%																																			

MARS

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Sep-94	NA	42%	109%	206%	241%	163%	80%	83%	83%	80%	108%	98%	88%	69%	60%	101%	75%	45%	109%	227%	103%	144%	69%	77%	57%	46%	369%	4%	146%	122%	57%	NA	74%	NA	3%	303%
Dec-94	27%	132%	133%	132%	164%	135%	135%	101%	87%	112%	89%	81%	78%	135%	99%	96%	106%	96%	127%	100%	62%	103%	61%	95%	101%	183%	43%	50%	40%	63%	78%	107%	197%	210%	91%	NA
Mar-95	26%	97%	134%	136%	117%	127%	95%	89%	85%	118%	146%	89%	80%	62%	66%	85%	72%	103%	121%	120%	74%	52%	73%	40%	99%	80%	230%	46%	38%	40%	148%	102%	108%	205%	89%	
Jun-95	NA	72%	128%	138%	219%	128%	89%	85%	101%	82%	102%	102%	191%	135%	87%	92%	109%	122%	86%	91%	92%	69%	270%	215%	70%	232%	53%	83%	64%	158%	70%	122%	82%	66%		
Sep-95	7%	105%	143%	178%	125%	117%	82%	76%	113%	77%	82%	78%	98%	131%	49%	109%	161%	121%	157%	92%	55%	101%	46%	93%	110%	48%	49%	37%	566%	49%	113%	31%	15%			
Dec-95	145%	109%	114%	121%	106%	80%	86%	103%	72%	97%	83%	82%	117%	79%	130%	114%	138%	105%	114%	93%	71%	63%	92%	61%	58%	123%	51%	28%	46%	51%	49%	21%				
Mar-96	NA	120%	113%	100%	116%	79%	103%	67%	87%	78%	74%	94%	89%	111%	80%	110%	86%	145%	73%	192%	42%	58%	56%	58%	64%	67%	71%	106%	44%	389%	29%					
Jun-96	NA	90%	103%	98%	104%	88%	80%	93%	97%	76%	93%	131%	103%	98%	99%	141%	111%	89%	86%	65%	274%	62%	63%	181%	105%	110%	77%	65%	54%	83%						
Sep-96	86%	82%	110%	120%	109%	96%	86%	106%	115%	111%	97%	117%	110%	124%	105%	78%	84%	87%	104%	112%	203%	67%	97%	134%	125%	72%	148%	156%	196%							
Dec-96	NA	79%	128%	107%	84%	86%	114%	99%	83%	99%	102%	109%	76%	89%	131%	64%	100%	115%	199%	72%	83%	141%	266%	58%	48%	60%	195%	161%								
Mar-97	NA	85%	105%	106%	91%	78%	95%	116%	107%	86%	137%	91%	113%	78%	71%	90%	92%	130%	143%	102%	129%	59%	430%	111%	99%	34%	144%									
Jun-97	NA	111%	123%	101%	89%	77%	112%	85%	104%	107%	96%	80%	80%	80%	94%	121%	135%	128%	69%	84%	108%	82%	126%	33%	73%	50%										
Sep-97	2%	80%	92%	100%	100%	93%	85%	89%	90%	102%	110%	141%	89%	154%	110%	98%	74%	81%	57%	91%	112%	86%	396%	103%	111%											
Dec-97	83%	63%	118%	94%	91%	100%	83%	130%	124%	107%	91%	81%	131%	84%	85%	114%	72%	83%	109%	68%	145%	43%	82%	44%												
Mar-98	NA	82%	98%	114%	84%	91%	95%	95%	103%	92%	59%	104%	93%	80%	153%	93%	67%	84%	88%	147%	111%	68%	45%													
Jun-98	NA	94%	108%	107%	99%	94%	109%	106%	109%	73%	95%	81%	100%	113%	78%	117%	82%	73%	90%	52%	39%	69%														
Sep-98	97%	95%	106%	106%	111%	117%	98%	102%	102%	104%	116%	94%	109%	77%	89%	146%	89%	116%	115%	170%	67%															
Dec-98	NA	88%	95%	110%	115%	102%	102%	98%	136%	81%	108%	103%	82%	93%	134%	89%	125%	115%	90%	98%																
Mar-99	7%	67%	109%	106%	87%	97%	74%	114%	86%	95%	88%	82%	72%	94%	91%	96%	77%	72%	92%																	
Jun-99	4%	73%	97%	104%	95%	98%	110%	107%	111%	115%	101%	79%	84%	79%	149%	103%	76%	120%																		
Sep-99	3%	70%	100%	106%	94%	108%	102%	95%	117%	95%	130%	94%	100%	106%	108%	139%	88%																			
Dec-99	9%	94%	107%	102%	116%	87%	101%	101%	94%	109%	104%	94%	98%	72%	99%	99%																				
Mar-00	86%	79%	84%	131%	88%	105%	88%	85%	89%	93%	96%	87%	141%	74%	83%																					
Jun-00	50%	65%	90%	92%	92%	94%	97%	96%	97%	92%	117%	107%	82%	95%																						
Sep-00	NA	101%	87%	91%	97%	120%	103%	124%	110%	99%	170%	102%	87%																							
Dec-00	4%	46%	53%	72%	73%	87%	92%	88%	89%	100%	106%	117%																								
Mar-01	14%	38%	57%	90%	75%	99%	109%	117%	102%	83%	86%																									
Jun-01	22%	50%	66%	68%	101%	99%	122%	117%	120%	93%																										
Sep-01	22%	53%	60%	102%	134%	120%	93%	109%	87%																											
Dec-01	24%	40%	61%	98%	121%	105%	127%	82%																												
Mar-02	28%	39%	79%	120%	101%	122%	94%																													
Jun-02	18%	54%	97%	108%	110%	118%																														
Sep-02	62%	48%	66%	116%	115%																															
Dec-02	144%	46%	73%	91%																																
Mar-03	21%	36%	33%																																	
Jun-03	42%	23%																																		
Sep-03	2%																																			

“3D Triangles”

- Log(average size of finalised claims)

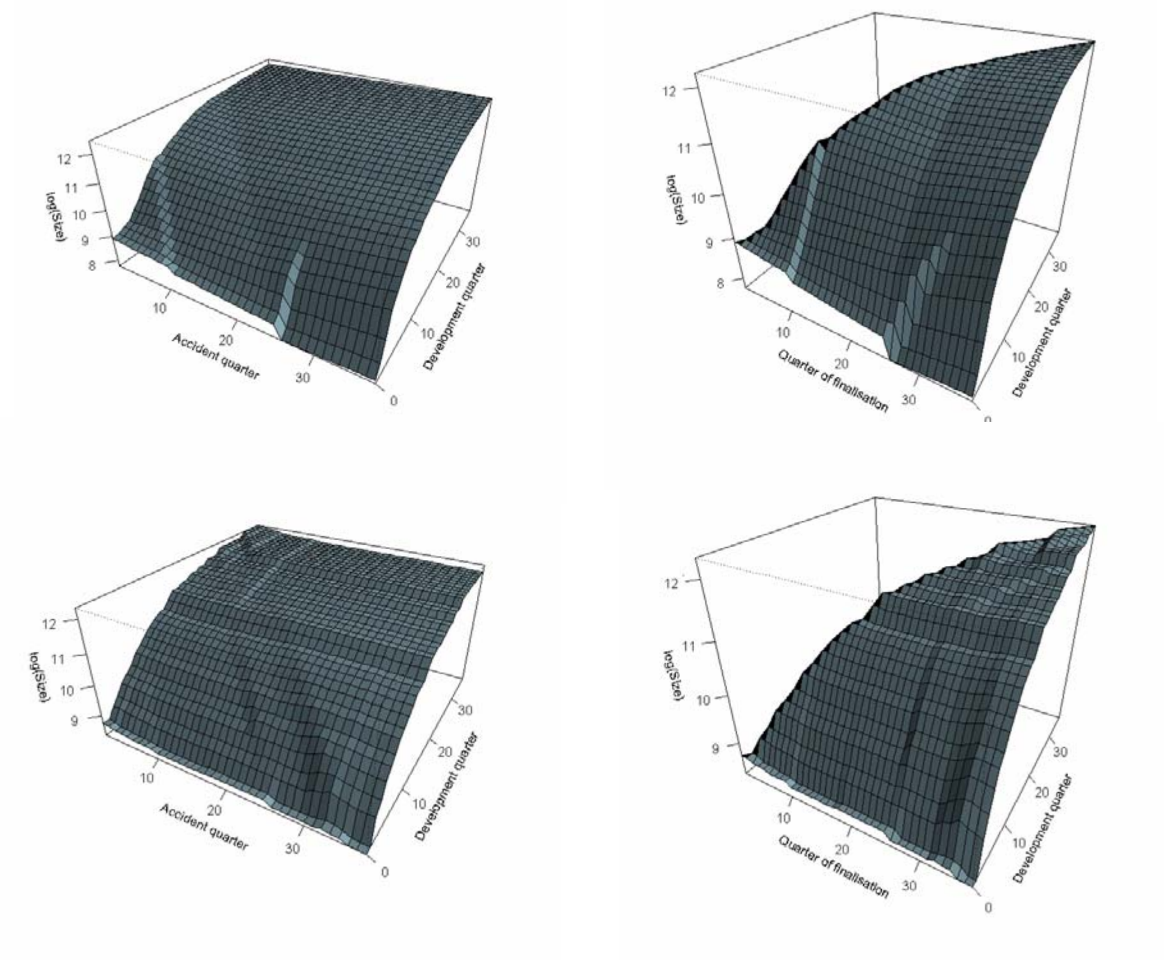


GLM

NN

"3D Triangles"

- Log(average size of finalised claims)



GLM

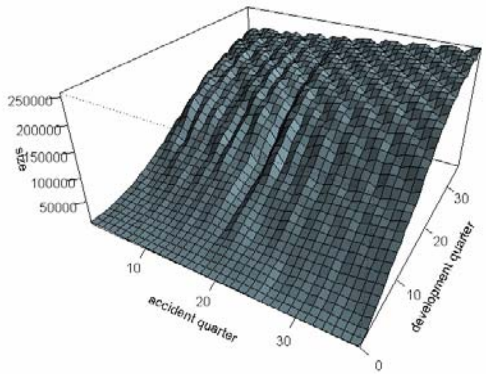
MART

Predictive accuracy

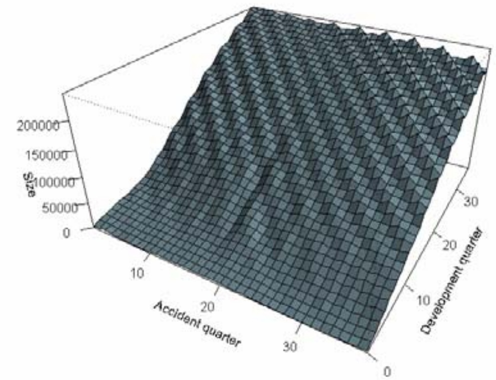
- Each model fitted to "training set" consisting of 2/3 of total data
- Remaining 1/3 of data used as "test set" to test the predictive accuracy

Model	Sum of squares	Average Absolute Error
GLM	2.000×10^{14}	33,777
Neural Network	1.996×10^{14}	33,476
MART	1.999×10^{14}	33,290
MARS	1.994×10^{14}	33,806

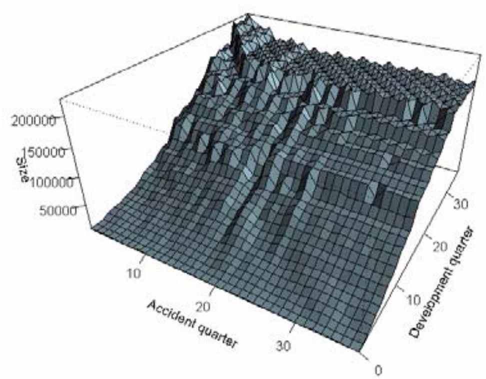
Projections of claim size



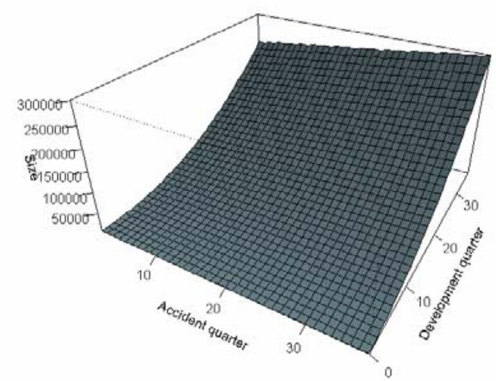
GLM



NN



MART



MARS

Summary

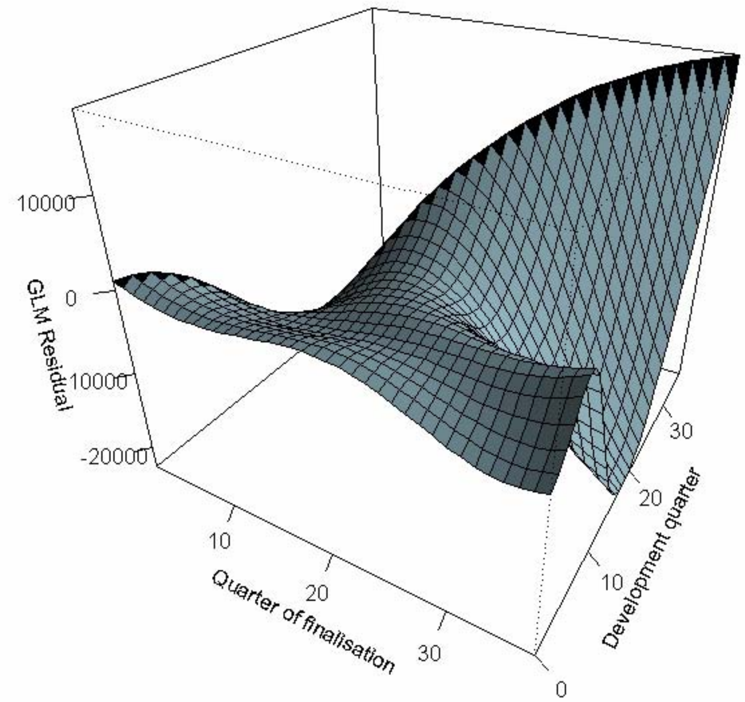
- Neural Networks and MART had better predictive accuracy than GLMs
- The soft-computing methods were largely automated and quicker to use
- Soft-computing models were less suitable for projecting claim sizes into future periods

Summary

- GLMs better for performing pricing and reserving projections
- Soft-computing techniques could play role in model checking
  - Assessing the prediction error of the GLM model
  - Help determine which interactions to include in the GLM model.

Summary

- Features remaining in the residuals from a "main effects" GLM model of claim size



Thank you