MONASH University

Engineering

A Mixed Logit Modelling Approach to Investigating At-Fault Accidents

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Agenda

1 Introduction - Mixed Logit (ML) Modelling

2 Bus Safety
- Literature Review
- Data & Methodological Issues

3 ML Modelling for At-Fault Accidents

4 Preliminary Results

5 Discussion / Conclusion / Q&A

Introduction – Mixed Logit Modelling

- Accident models are typically developed in road safety research
  - ✓ Crash count, severity, potential, etc.

E.g. $\lambda_i = \exp(\beta X_i + \varepsilon_i)$

Vehicle

Driver

Roadway / Environmental

- Parameters X_i assumed to be fixed across observations, e.g. roads with comparable characteristics taken to be similarly correlated to accident risks
- In reality, heterogeneity across observations may exist, e.g. risk perception is likely to vary across drivers
- Constraining parameters to be constant when they actually vary could lead to inconsistent and bias parameter estimates (Washington et al., 2003)
- Potential of using mixed logit modelling as parameters are allowed to vary, thus accounting for heterogeneity in data

Bus Safety – Study Focus

- Current study focuses on understanding key factors in influencing bus driver being at-fault in bus-involved accidents

- Limited knowledge on factors influencing bus accidents and in particular culpable accidents (Wahlberg, 2004)

- Public transport a very safe mode of transport (Chimba et al, 2010); KSI risks for bus occupants several times lower as compared to car occupants (Albertsson & Falkmer, 2005)

Bus Safety - Literature Review

- Summary of Previous Studies on Bus Accidents

Author	Key Accident Risk Factors Examined / Found																			
	 Age	Experience	Gender	Work Hours	Temperament	Mileage	 Buses with lift	AVL System	Turning Bus	Side-swipe	Rear-end	Frontal Impacts	 On-street parking	Lane bus was in	Posted speed limit	Lane width	Traffic volume	Sight Obstruction	Crossing Pedestrians	Time of Day
Yang et al. (2009)	✓								✓		✓									
Zegeer et al. (1993)										✓	✓									
Strathman et al. (2010)	✓	✓	✓	✓	✓		✓													
Jovanis et al. (1991)											✓									
Tseng (2012)	✓	✓																		
Chimba et al. (2010)		✓				✓		✓												
af Wåhlberg (2009)													✓	✓	✓	✓	✓	✓		
Albertsson and Falkmer (2005)												✓			✓					
Brenac and Clabaux (2005)																		✓	✓	
af Wåhlberg (2004)				✓	✓															✓

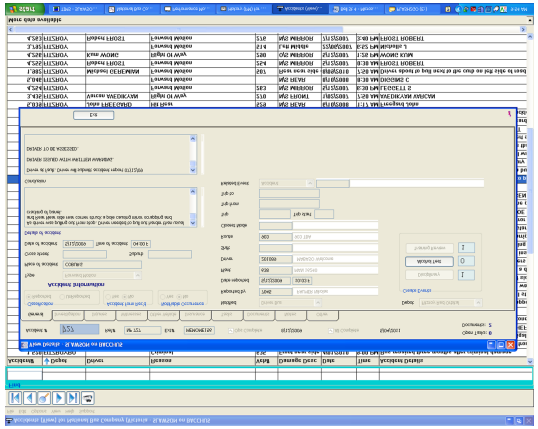
- Previous studies fallen short of:
  - ✓ Representing all safety determinants - confounders not captured
  - ✓ Allowing for possible heterogeneity across observations
  - ✓ Understanding at-fault accidents (only 1 study previously)

Bus Safety - Data and Methodological Issues

- Self-reported - under-reporting, recency effects, socially desirable answers
- Surveys - sampling bias, failing to obtain representative sample
- Limited data on all 3 safety determinants
- Quality of data on at-fault accidents
  - ✓ Assessment of “at-fault” can be contentious

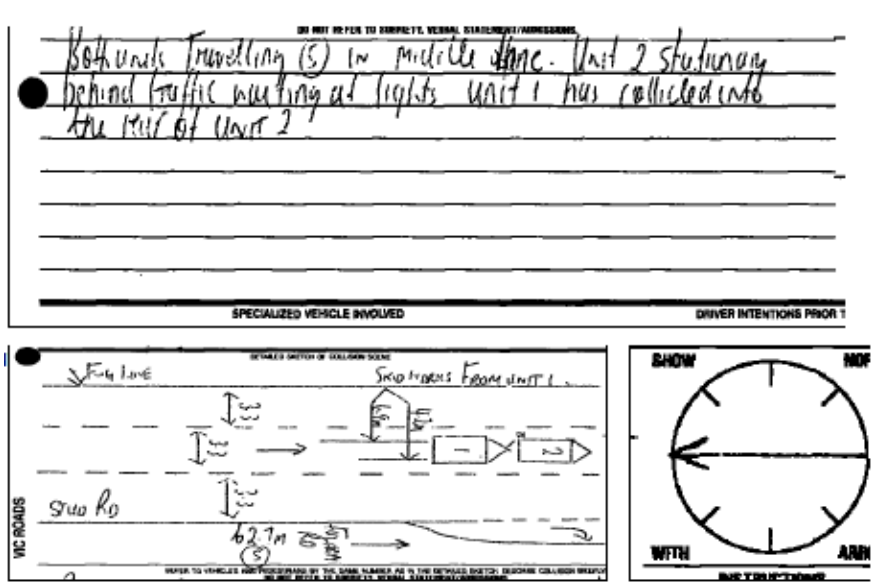
Bus Safety - Data and Methodological Issues

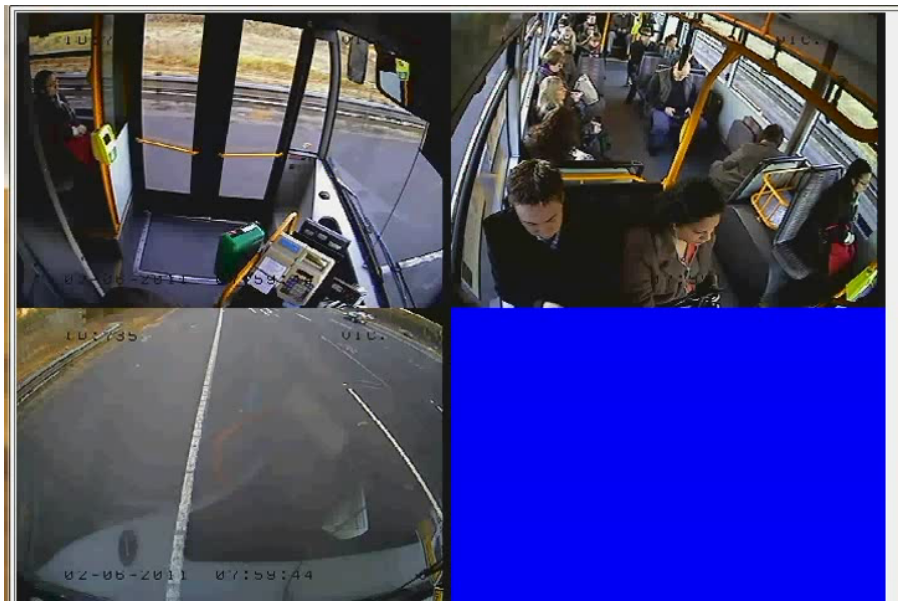
- In light of above issues, bus accident data in current study obtained from TIM database from bus company in Metropolitan Melbourne
  - ✓ Data quality considered to be better than police records / self-reported survey returns
  - ✓ More objective assessment of responsibility in bus accidents with adjusters from insurance companies involved and use of photo and CCTV footage as evidence



Bus Safety - Data and Methodological Issues

- Data Quality - An illustration

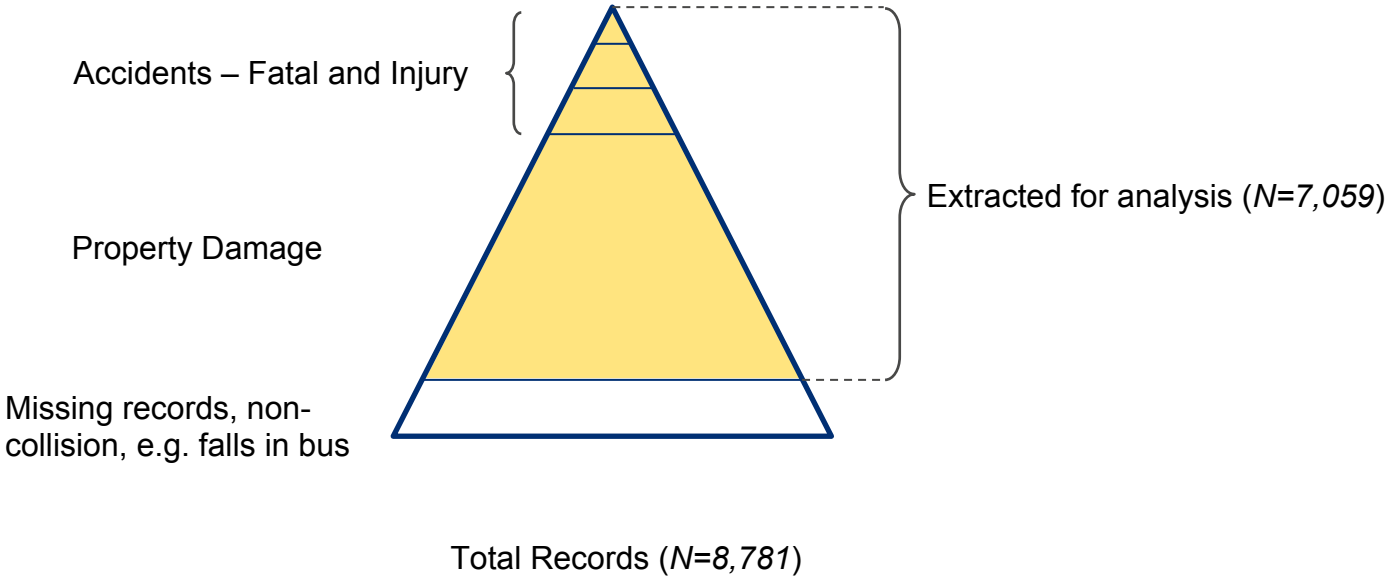




Police Record vs. CCTV video recordings

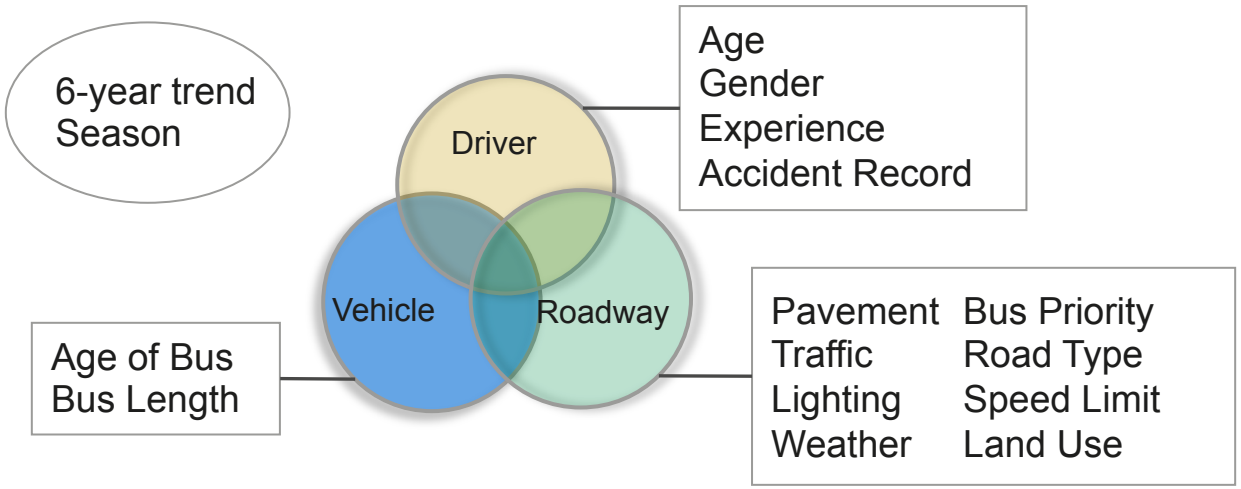
Data for Current Study

- Total of 8,781 incidents along 99 bus routes (year 2000 to 2011)
- Only collision data (accidents) were used
- Records with missing fields and non-collision data were excluded
- Final dataset = 7,059 accidents



Data for Current Study

- Data included driver, roadway, environmental factors (16 in total)



- Nature of Dataset
  - ✓ Certain driver-specific attributes, e.g. education level, risk perception which are not captured could influence at-fault probability
  - ✓ A number of drivers have multiple accident records

Most suited for ML modelling

Mixed Logit Modelling for At-Fault Accidents

- Mixed Logit Model of driver being at-fault:

$$F_{in} = \beta_i X_{in} + \varepsilon_n \quad (1)$$

where *i* = at-fault (=1) or not at-fault(=0) for driver *n*
X = *Vector of 16 factors;* ϵ as disturbance term

- For each driver, probability of at-fault category *i* for driver *n*:

$$P_n(i) = \frac{\exp(\beta_i X_{in})}{\sum_I \exp(\beta_i X_{in})} \quad (2)$$

- To allow for parameter variation across drivers, at-fault probability takes on:

$$P_{in} = \int P_n(i) f(\beta|\varphi) d\varphi \quad (3)$$

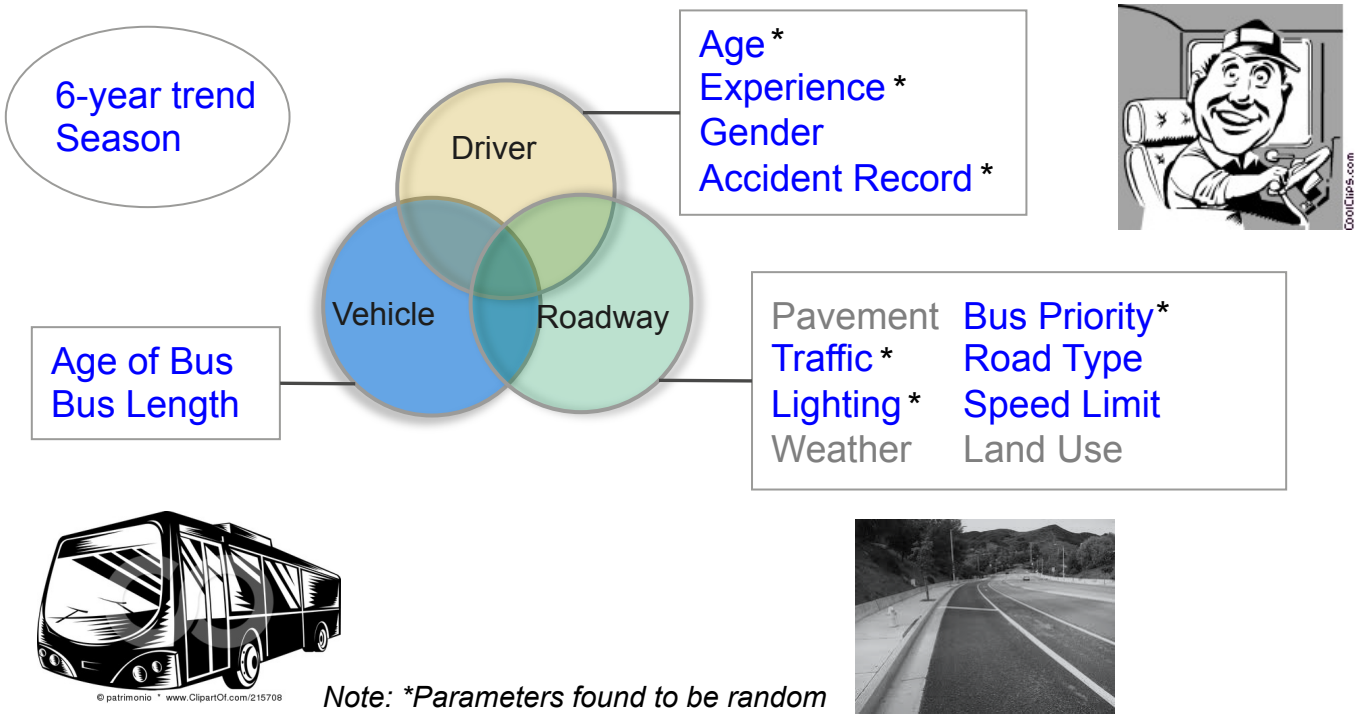
Functional form specified by researcher, typically, normal, log-normal, uniform, triangular.

- Probability approximated through simulation (Halton draws):
  - ✓Draw value of β from f($\beta|\varphi$)
  - ✓Calculate equation (2)
  - ✓Repeat steps above up to specific number of times and average results

$$SLL = \sum_{n=1}^{N} \sum_{j=1}^{J} F_{nj} ln \hat{P}_{nj}$$

Preliminary Results

- 13 out of 16 factors found to be statistically significant at 95% level with plausible signs



- Parameters considered random if their S.E. found to be significantly different from zero, else set to be fixed (6 of 14 factors)

Preliminary Results

- 13 out of 16 factors found to be statistically significant at 95% level with plausible signs
- 4 driver factors statistically significant

Age*
Experience*
Gender
Accident Record*

	Factor	Type	β	S.E.	t-Statistic
↑	Age - 60 years & above	Random	0.199 (0.575)	0.0419 (0.0492)	4.75 (11.69)
↑	Experience - 2 years or less	Random	0.179 (0.580)	0.0371 (0.0430)	4.83 (13.48)
↓	Gender - Male	Fixed	-0.171	0.0460	-3.72
↑	At-Fault Record	Random	0.130 (0.299)	0.0391 (0.0331)	3.31 (9.02)

At-fault likelihood increases for drivers aged 60 and above.

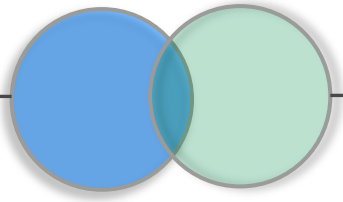
Likelihood increases for 63.5% of drivers

- At-fault probability increases for drivers above 60, with less than 2 years of working experience, are female and had previous at-fault accidents

Preliminary Results

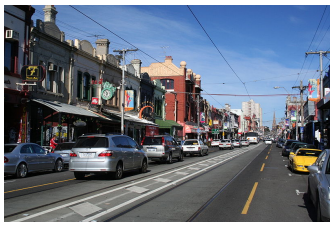
- 2 vehicle and 5 roadway / environmental factors found significant

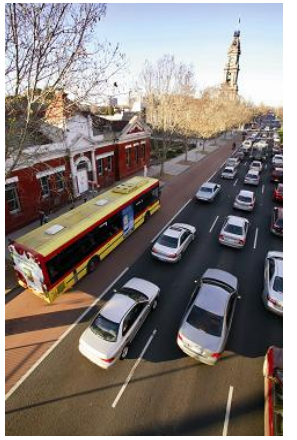
Age of Bus
Bus Length



Pavement	Bus Priority*
Traffic*	Road Type
Lighting*	Speed Limit
Weather	Land Use

	Factor	Type	β	S.E.	t-Statistic
↑	Bus age - 25 years or more	Fixed	0.273	0.0969	2.82
↓	Bus Length - 12m or less	Fixed	-0.241	0.0415	-5.81
↓	Divided Road	Fixed	-0.427	0.0501	-8.53
↑	Speed Limit - 50kph & below	Fixed	0.313	0.0404	7.73
↓	Traffic - Moderate/Heavy	Random	-0.206 (0.400)	0.0370 (0.0363)	-5.57 (11.03)
↓	Daylight	Random	-0.125 (0.418)	0.0449 (0.0297)	-2.78 (14.05)
↓	Bus Priority	Random	-0.446 (2.26)	0.216 (0.447)	-2.07 (5.05)





Indicative that divided roads and those with bus priority would help bus drivers

Discussion - Factors increasing at-fault probability

Driver-related

- Above 60 year old - possibly reflecting declining driving skills
- <2 years working experience - also found in previous study (Tseng, 2012)
- Female driver
- Previous at-fault record - presence of accident prone mentality

Vehicle-related

- Longer / older buses - not surprising given buses are likely to be less responsive and had been subjected to greater wear-and tear

Roadway / Environment

- Undivided / 50kph or lesser roads - indicate space issues faced by bus drivers, especially near bus stops (Wahlberg, 2002)
- Light traffic - perhaps drivers letting guard down
- Night time - lesser visibility
- Lack of bus priority - space issue as highlighted

For road / bus agencies, findings suggest benefits in assigning

✓ Longer / older buses to experienced drivers

✓ Routes with bus priority and mainly arterial roads to less experienced drivers

Summary / Conclusion

- Assumptions in traditional safety models
  - ✓ Potential of using Mixed Logit Modelling to account for heterogeneity in data, e.g. human-specific attribute, and provide fuller understanding of factors determining variable of interest
- Studies on bus accidents
  - ✓ Data and methodological issues with using crash records and self-reported data
  - ✓ Fallen short of representing all safety determinants
- ML modelling on at-fault probability of bus drivers in accidents
  - ✓ Model results show some attributes vary across drivers, e.g. age, experience
  - ✓ Findings point to benefits in assigning routes with lesser space constraints and shorter buses from younger fleet to less experienced drivers

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