Is the front passenger seat always the “death seat”?

An application of hierarchical ordered model for occupant injury severity

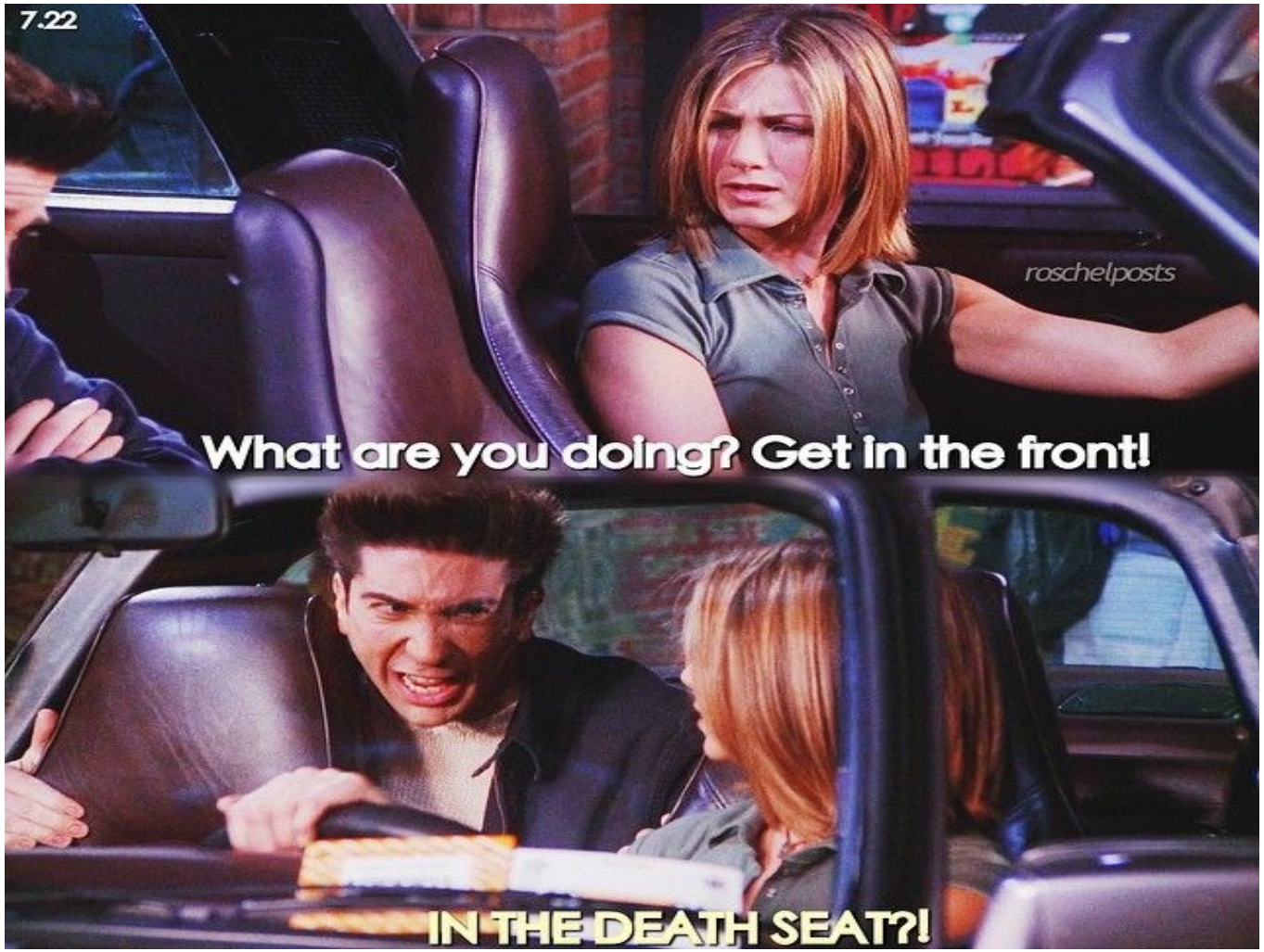
Authors:
Dr. Hongtai Yang, Associate Professor, Southwest Jiaotong University
Mr. Guocong Zhai, GRA, Southwest Jiaotong University
Dr. Jun Liu, Assistant Professor, The University of Alabama

Presented by:

Jun Liu

Contact: jliu@eng.ua.edu

Background



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Research Objective

Seat Positions

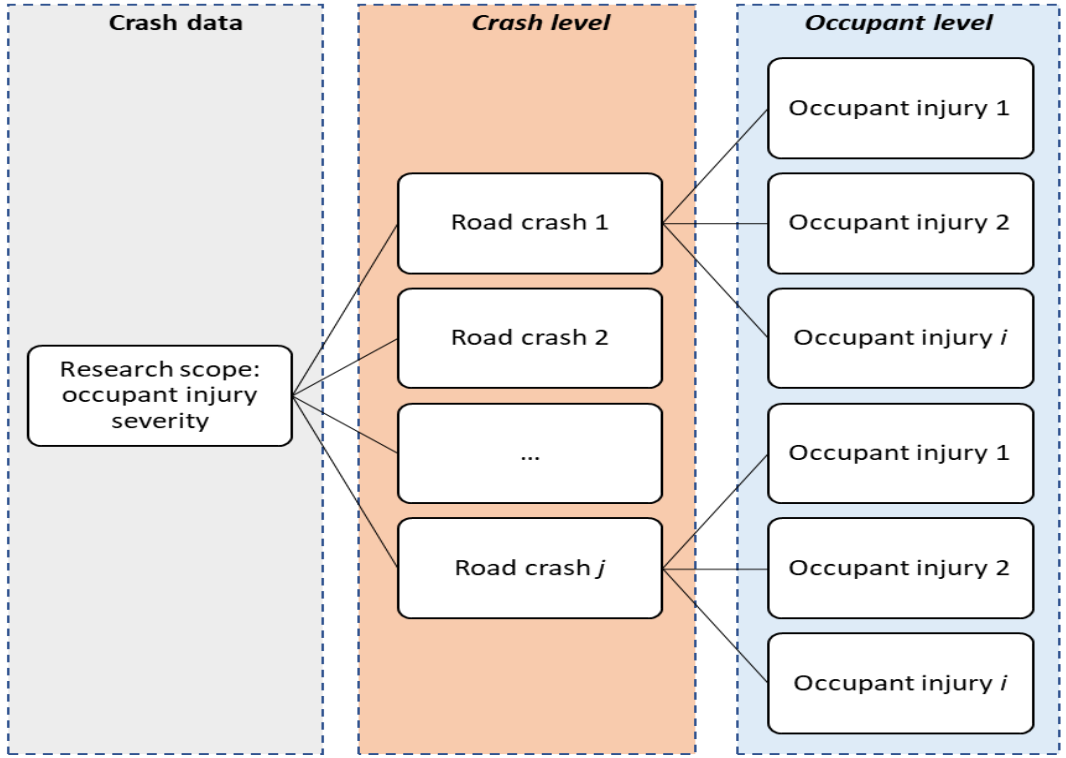
- Driver seat
- Front left passenger seat
- Front middle passenger seat
- Rear left passenger seat
- Rear middle passenger seat
- Rear right passenger seat

Correlation

Occupant Injury Severities

- No visible injury
- Moderate injury
- Severe injury
- Fatal

Modeling Framework



Research Question- How to account for injuries of all occupant in a crash?

Modeling Framework

- Hierarchical Ordered Model

$$p_{ij} = \Pr(y_{ij} = c | X_{ij}, v_j) = \frac{1}{1+\exp(-\gamma_c + X_{ij}\beta + Z_{ij}v_i + \epsilon_{ij})} - \frac{1}{1+\exp(-\gamma_{c-1} + X_{ij}\beta + + Z_{ij}v_i + \epsilon_{ij})}$$

  - y_{ij} = injury severity of occupant *j* involved in crash *i*;
  - c = injury severity level, c = 1, 2, 3, and 4;
  - X_{ij} = a (1 × p) vector of covariates corresponding to fixed effects;
  - β = fixed effects parameter for covariates X_{ij};
  - Z_{ij} = a (1 × q) vector of covariates corresponding to random effects;
  - v_i = random effects parameter at crash event level;
  - γ_c = threshold value for injury severity level c,$\gamma_0 = -\infty$ and $\gamma_4 = +\infty$;
  - ϵ_{ij} = model residuals $\epsilon_{ij} \sim N(0, \delta^2)$.

Data

- Dataset about road crash
- South Australia
- From 2012 to 2016
- 20,347 occupant injuries in 16,420 motor vehicle crashes (after data cleaning and error check)

Source: https://en.wikipedia.org/wiki/South_Australia

Data

Injury Severity	Frequency
No Visible Injury	35.08%
Moderate Injury	56.62%
Severe Injury	7.03%
Fatal	1.26%

N = 20,347 occupants

Seat Positions	Frequency
Driver seat	78.39%
Front middle passenger seat	0.05%
Front left passenger seat	15.05%
Rear right passenger seat	2.78%
Rear middle passenger seat	0.78%
Rear left passenger seat	2.96%

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Bucket seat

From Wikipedia, the free encyclopedia

A **bucket seat** is a car seat cont
seat designed to fit multiple pec
with high sides, but may have
high-performance automobile

Bucket seats first appeared
European cars with floor-m
typically standard in front
turning at speed. Rear "b
being contoured genera
console, and thus lacki
adjustability.

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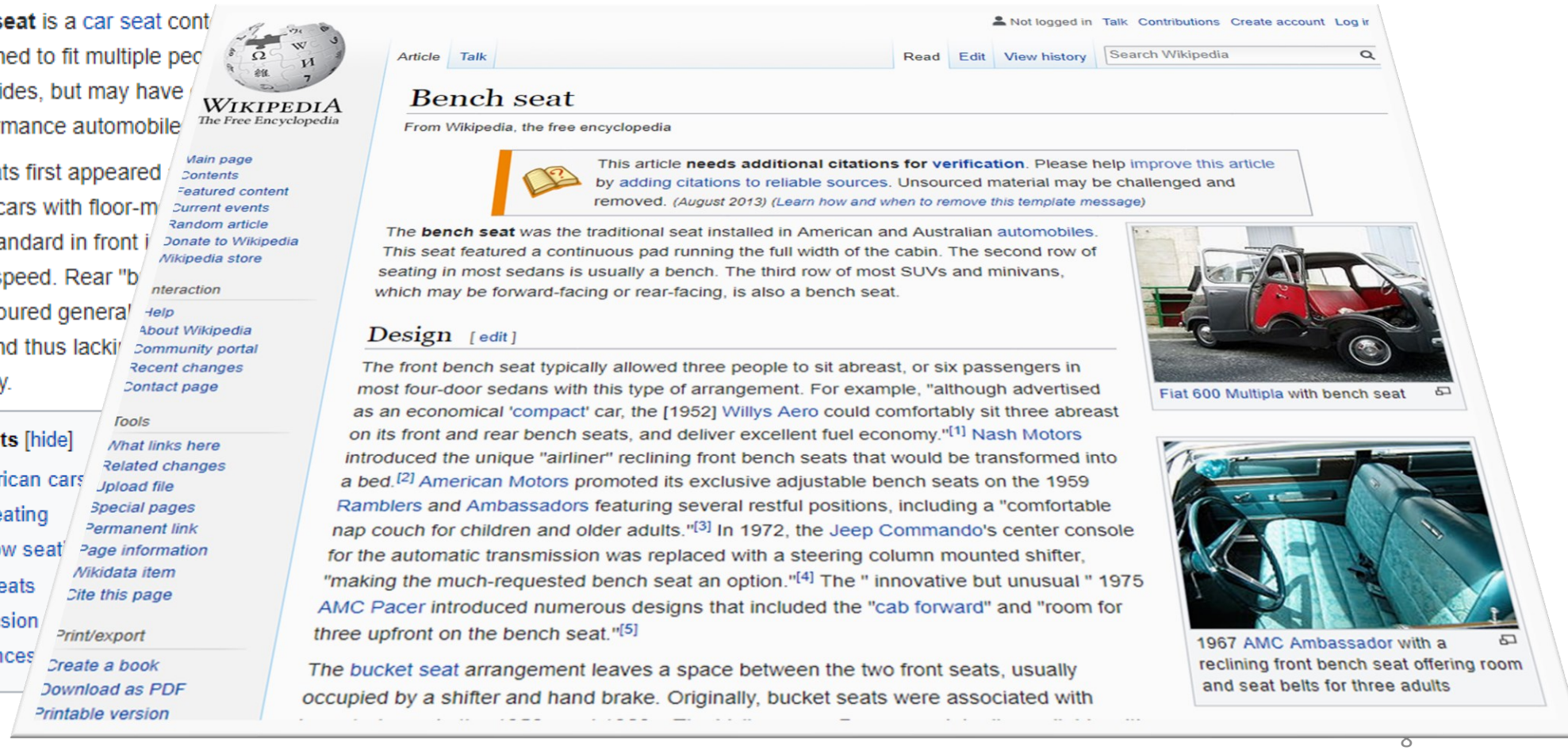
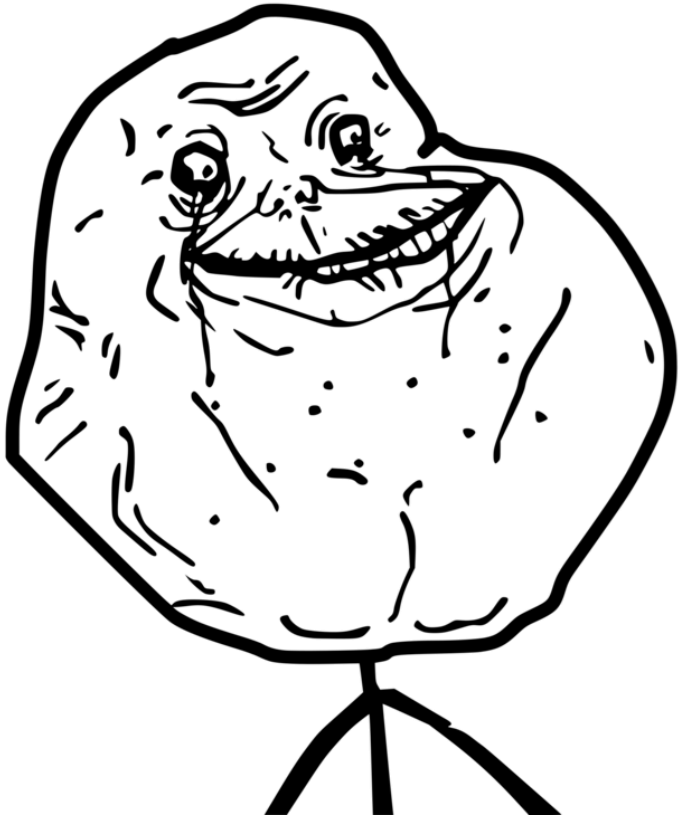


Model Results



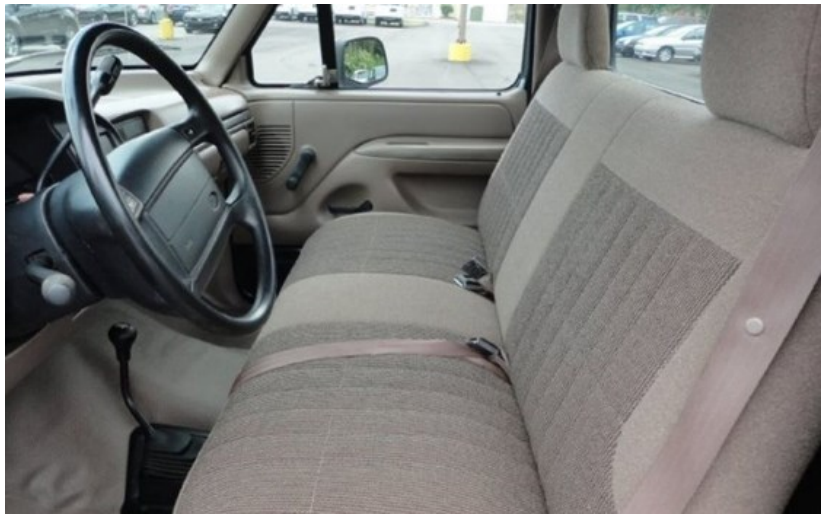
Variables (Dependent variable = injury severity)		β	P > |z|	[95% Conf. Interval]	
Injury age		0.009	0.000	0.005	0.013
Injury position in the vehicle Base: Driver seat	Front middle passenger seat = 1	4.541	0.055	-0.100	9.183
	Front left passenger seat = 2	0.418	0.005	0.128	0.709
	Rear right passenger seat = 3	0.969	0.002	0.344	1.593
	Rear middle passenger seat = 4	1.480	0.012	0.325	2.635
	Rear left passenger seat = 5	0.961	0.002	0.348	1.573
Injury seat belt Base: No worn		-1.051	0.000	-1.273	-0.829
Driver age		-0.052	0.000	-0.062	-0.041
Driver age^2		0.001	0.000	0.0007	0.0009
License type Base: Unlicensed	Conditional = 1	-0.422	0.001	-0.673	-0.172
	Full = 2	-0.599	0.000	-0.838	-0.361
Vehicle year	Vehicle production year	-0.011	0.000	-0.016	-0.006
Area speed	The value of speed limit	0.022	0.000	0.019	0.024
Stats area Base: City	Metropolitan = 1	0.244	0.015	0.047	0.441
	Country = 2	0.932	0.000	0.701	1.163
Time attribute	Weekday Base: Weekend	-0.147	0.002	-0.237	-0.056
	Night Base: Daylight	0.351	0.000	0.259	0.443
	Peak hour Base: No peak time	-0.183	0.000	-0.265	-0.101
Location on the road Base: No intersection	Intersection of no signal control = 1	-0.108	0.026	-0.202	-0.013
	Intersection of signal control = 2	-0.341	0.000	-0.447	-0.235
Crash type Base: Rear end	Right angle = 1	1.245	0.000	1.129	1.361
	Hit fixed object = 2	1.968	0.000	1.819	2.117
	Right turn = 3	1.691	0.000	1.547	1.835
	Side swipe = 4	0.535	0.000	0.374	0.697
	Roll over = 5	1.601	0.000	1.379	1.823
	Head on = 6	2.402	0.000	2.165	2.639
	Others = 7	1.478	0.000	1.270	1.687
Abuse	Drugs involved Base: No drugs	1.213	0.000	1.016	1.409
	Alcohol involved Base: No alcohol	0.690	0.000	0.489	0.891
Interaction between injury position in the vehicle and area speed	Front middle passenger seat*area speed	-0.047	0.081	-0.100	0.006
	Front left passenger seat * area speed	-0.004	0.027	-0.008	0.000
	Rear right passenger seat * area speed	-0.010	0.016	-0.018	-0.002
	Rear middle passenger seat * area speed	-0.017	0.024	-0.031	-0.002
	Rear left passenger seat * area speed	-0.007	0.065	-0.015	0.000
Constant	γ1	-22.540	—	-32.126	-12.953
	γ2	-18.248	—	-27.816	-8.679
	γ3	-1.226	—	-25.788	-6.663
Reported ID	Var(constant)	2.661	—	2.377	2.980
Random-effects Parameters		Estimate			
Log Likelihood at β		-14686.352			
Log Likelihood at 0		-18951.948			
Pseudo-R2		0.22			
Wald χ2		1771.84			
LR test vs. oprobit: χ2		1582.78			
Prob. ≥ χ2		0.000			

Notes: STATA software (meologit program) was used.

Pseudo-R2 - refers to 1 – (Log Likelihood at β/Log Likelihood at 0).

Model Results

Variables (Dependent variable = injury severity)		β	P > |z|	No visible injury	Moderate injury	Severe injury	Fatal
Injury age		0.009	0.000	-0.28%	0.28%	0.00%	0.00%
Injury position in the vehicle Base: Driver seat	Front middle passenger seat = 1	4.541	0.055	-23.50%	22.25%	1.25%	0.00%
	Front left passenger seat = 2	0.418	0.005	-3.71%	3.70%	0.01%	0.00%
	Rear right passenger seat = 3	0.969	0.002	-8.35%	8.32%	0.03%	0.00%
	Rear middle passenger seat = 4	1.480	0.012	-10.28%	10.24%	0.04%	0.00%
	Rear left passenger seat = 5	0.961	0.002	-12.41%	12.35%	0.06%	0.00%



Model Results

- senior occupants
- higher traffic speeds
- daytime (vs. night time)
- Hit fixed object (vs. rear end)
- head on (vs. rear end)
- intoxication

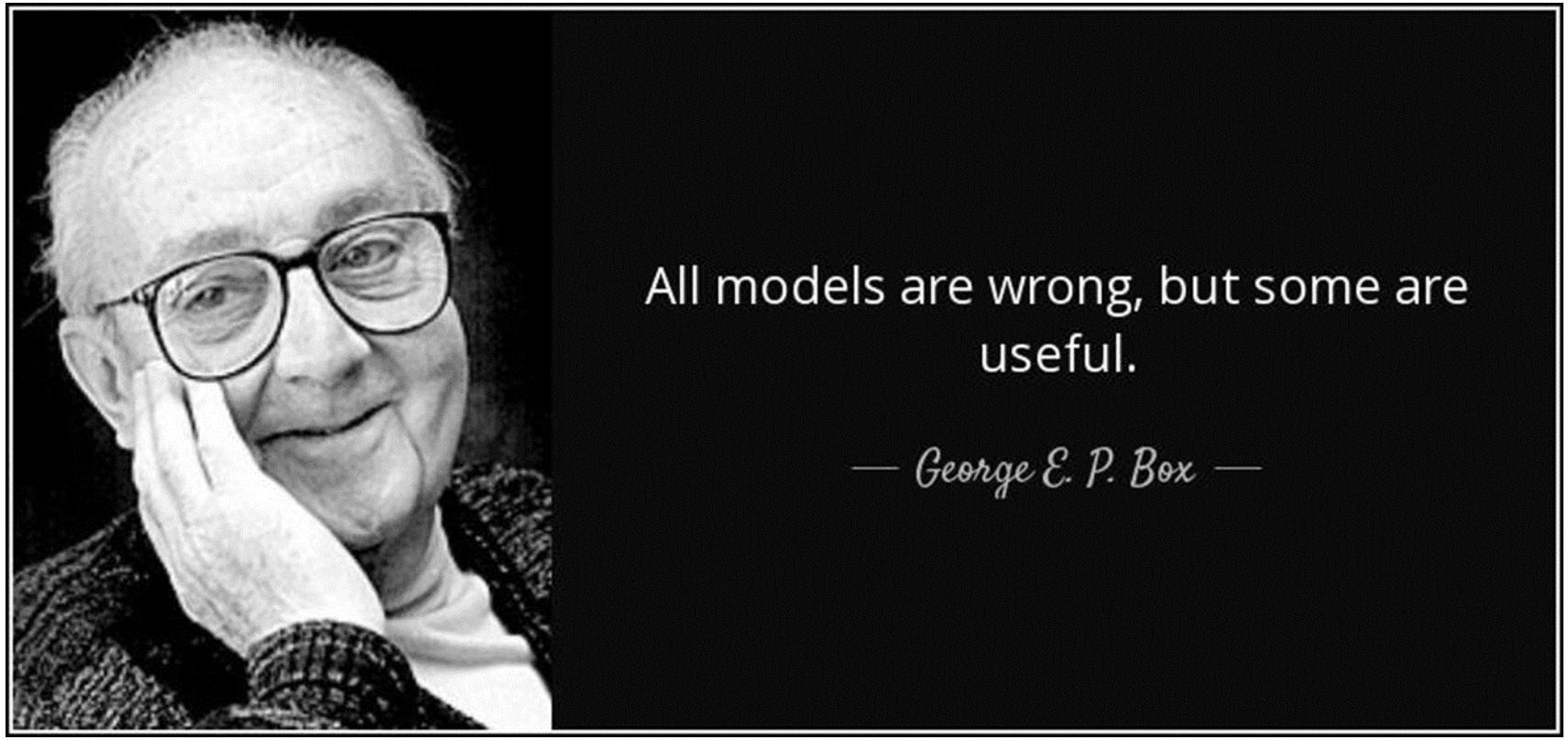
increases

injury severity

decreases

- seat belt use
- younger occupants
- weekends (vs. weekdays)
- intersection (vs. non-intersection)

Model Results



Some Insights

- Likelihood of severe injuries in a car crash:
  - front middle > rear middle > rear right > rear left > front left > driver seat

Thank You!

西南交通大學
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