Effect of Road Characteristics and Driving Cycles on Accident Risk on Full-Access-Control Highways

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September 29, 2016

Presentation Overview

1. Introduction
2. Data Processing
3. Methodology of Correlation
4. Model Implementation
5. Summary

Introduction

Driving Cycles

- Driving cycles have been developed to provide a single speed-time profile that is representative of driving.

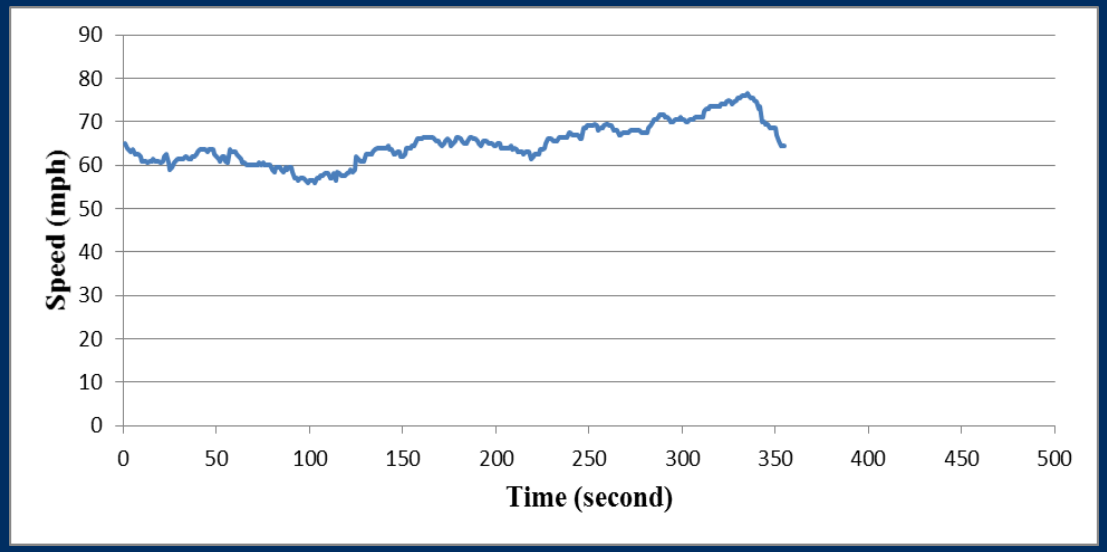


Figure 1 Example of Driving Cycle

Usage

- Estimating vehicle emissions and fuel consumption.
- Can driving cycles be used for traffic safety?

Existing Studies

Crash Analysis

- Traffic Characteristics: higher speed will lead to high crash rate.
- Roadway features: Median types, surface condition and horizontal curves can affect crash severity.

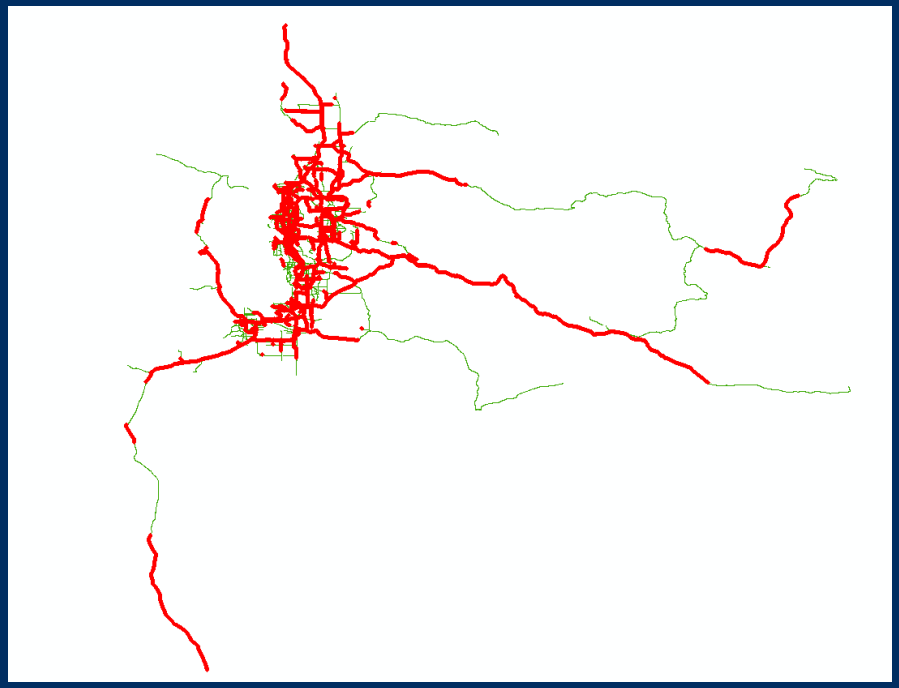
Limitation of previous studies

- The relationship between speed integrating road conditions and crash risk is still not well understood.
- Driving cycles still have not been involved in traffic safety.

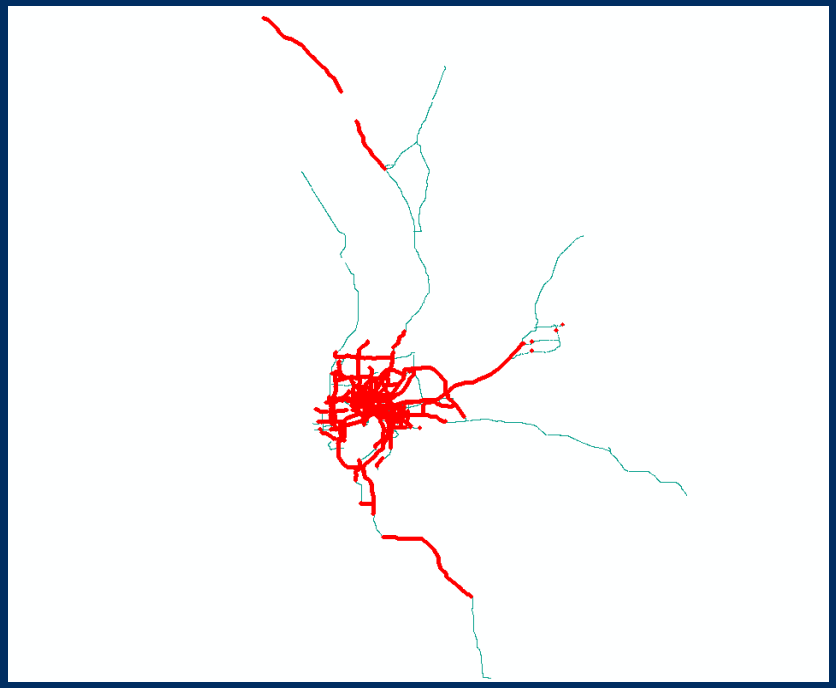
Data Source

Data Source

- The Strategic Highway Research Program 2 (SHRP 2) naturalistic driving study (NDS) data.
- Related Road Information Database (RID).



(a) WA



(b) FL

Figure 2 NDS Map

Crash Data

Crash data on full-access-controlled highways from year 2006 to 2012 were extracted. A total of 4,849 road segments with crash rate information were extracted.

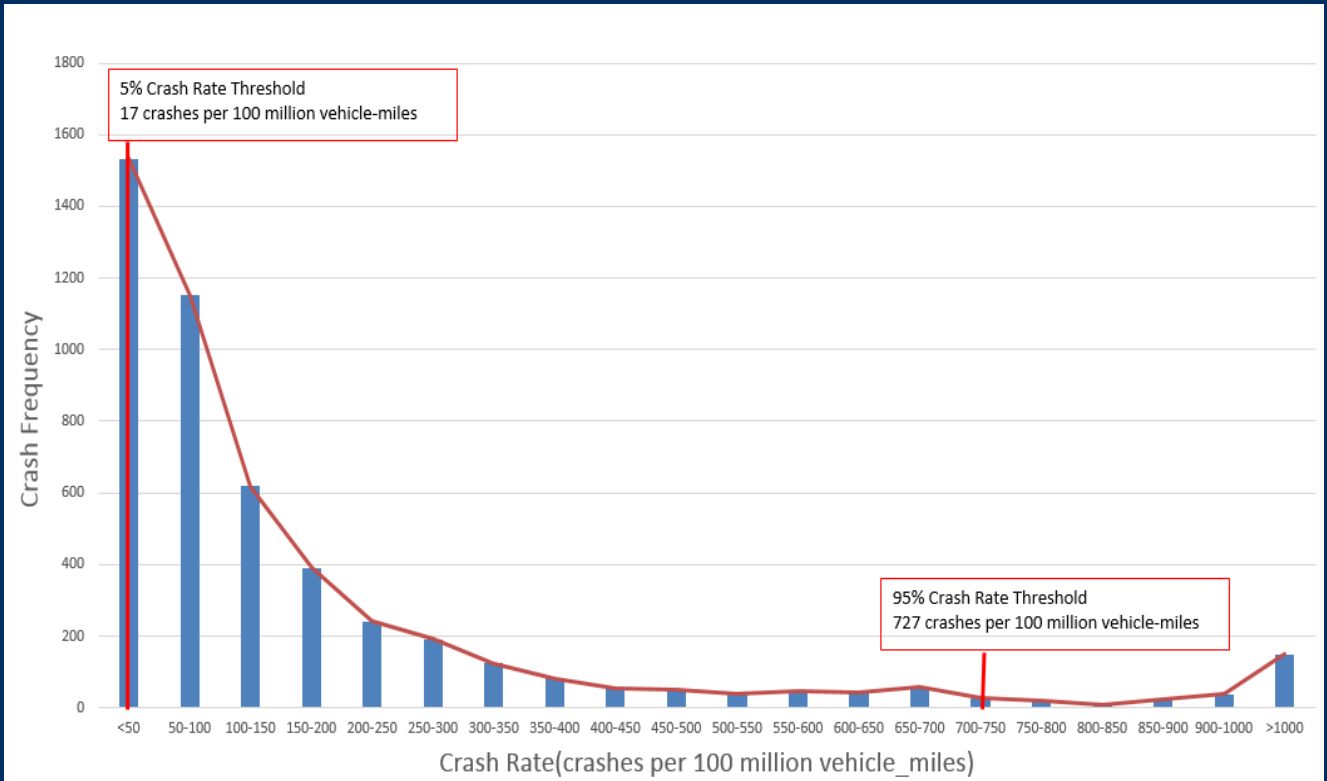


Figure 3 Distribution of Crash Rate

Driving Cycles Developments

- Light duty vehicles on full-access-control highways were used for developing driving cycles.
- The driving cycle procedure took the roadway properties of the functional system, area, through lane number, speed limit, horizontal curve level, LOS and grade level into consideration . Table 2 shows different scenarios.

Driving Cycles Developments

Table 2 Driving cycles on full-access-controlled highways

Driving Cycles ID	F SYSTEM	Area	Through Lane	Speed Limit (mph)	Curve Level	Grade Level	Average Speed (mph)	Min. Speed (mph)	Max. Speed (mph)	Speed Var.
1	1	R	2	70	A	A	72.621	62.000	84.779	19.192
2	1	R	2	70	A	B	71.564	60.182	82.227	17.090
3	1	R	2	70	A	C	70.955	62.962	79.004	10.797
4	1	R	2	70	C	C	70.955	62.962	79.004	10.797
5	1	R	3	60	A	B	70.256	60.983	80.508	15.819
6	1	R	3	70	A	A	70.701	60.802	82.000	18.673
7	1	R	3	70	A	B	70.662	60.758	81.325	17.271
8	1	R	3	70	A	C	69.950	58.565	78.376	17.226
9	1	U	2	60	A	A	67.249	53.501	80.248	32.415
10	1	U	2	60	A	B	67.586	55.465	80.224	27.097
11	1	U	2	60	A	C	67.677	55.872	79.315	20.962
12	1	U	2	70	A	A	72.621	60.279	84.151	31.053
13	1	U	3	60	A	C	62.805	54.932	70.841	8.892
14	1	U	3	70	A	A	72.621	60.279	84.151	31.053
15	1	U	3	70	A	B	70.916	54.162	82.714	34.877
16	1	U	3	70	A	C	69.493	59.537	78.890	22.055
17	1	U	5	70	A	A	72.621	60.279	84.151	31.053
18	1	U	7	70	A	A	72.621	60.279	84.151	31.053
19	1	U	8	70	A	A	72.621	60.279	84.151	31.053
20	2	R	2	60	A	B	64.251	55.502	75.009	22.684
21	2	R	2	70	A	A	70.328	64.500	76.488	5.027
22	2	U	2	50	A	A	59.166	49.547	68.262	14.573
23	2	U	2	50	A	B	62.664	50.819	75.205	27.127
24	2	U	2	60	A	A	63.747	52.654	74.736	18.862
25	2	U	2	60	A	B	63.253	51.438	73.000	20.101
26	2	U	2	60	A	C	62.847	51.659	73.052	15.874
27	2	U	3	60	A	A	65.436	51.855	75.232	21.332
28	2	U	3	60	A	B	66.815	54.635	76.846	21.393
29	2	U	3	60	A	C	65.920	58.832	72.500	9.031

Note: R: Rural
U: Urban

Methodology of Correlation

Negative Binomial Regression

Advantage: Handle overdispered data and categorical data better than other models.

Regression in R

Functional systems, area type, curve level, and grade level should be considered as dummy variables because they are categorical data.

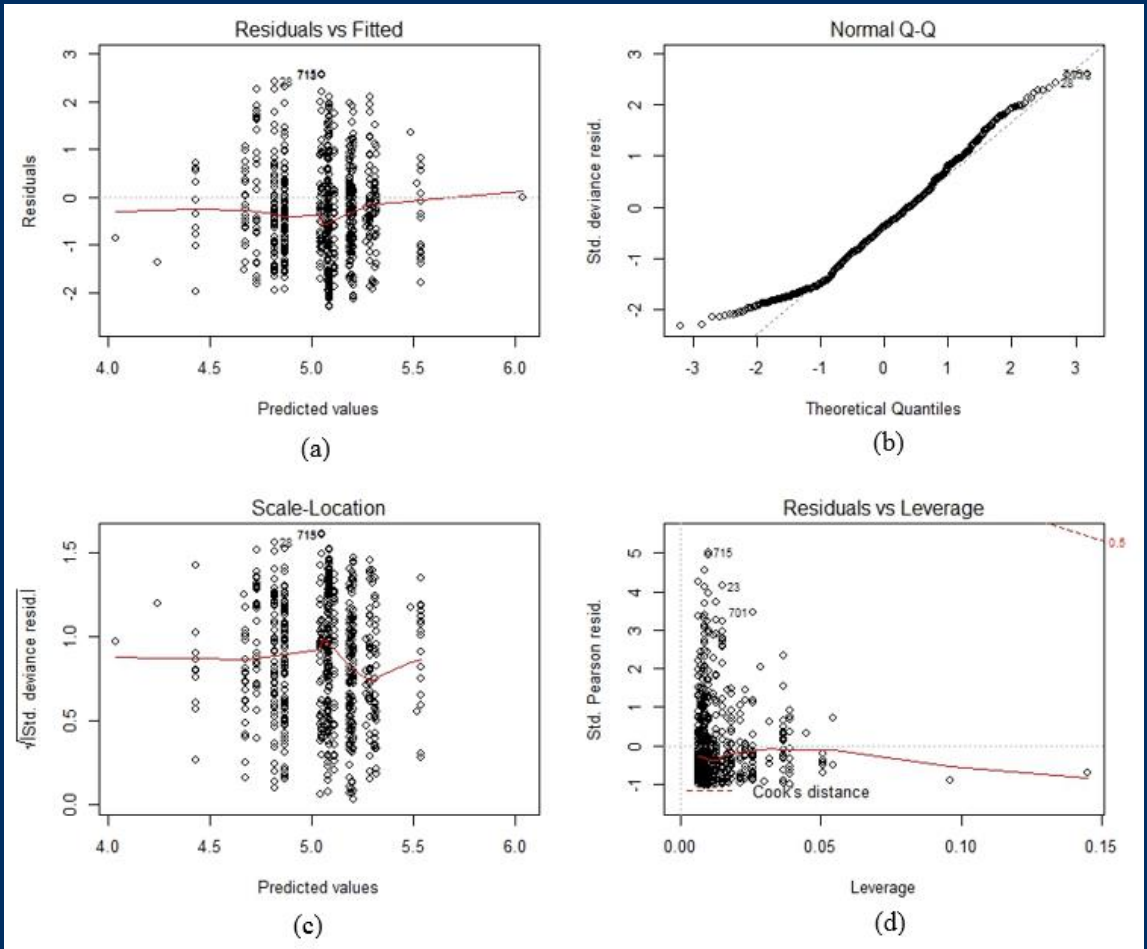
Table 3 Variables of negative binomial model

Variables	y	x1	x2	x3	x4
	Crash Rate	F_SYSTEM	Area	Through Lane	Speed Limit
Type	numeric	dummy variable	dummy variable	numeric	numeric
Variables	x5	x6	x7	x8	
	Curve Level	Grade Level	Average Speed	Speed Variance	
Type	dummy variable	dummy variable	numeric	numeric	

Model Implementation

- Model Validity

Figure 3 Diagnostics plot of negative binomial model



(a) No non-linear patterns in residuals.
(b) Normal distribution.
(c) None of the values of the vertical axis is greater than 2.
(d) Existence of leverage points may be caused by other variables, such as International Roughness Index (IRI), not covered in the model.

Implementation

- Regression Result (shown in Table 4)

Table 4 Summary of R output

	Coefficient	Std.Error	z value	Pr(>|z|)	Significant Level
(Intercept)	1.420826	1.561834	0.91	0.362972	
F_SYSTEM Principal Arterial - Other Freeways and Expressways	-0.094639	0.156742	-0.604	0.545983	
URBANCODE URBAN	0.637584	0.167598	3.804	0.000142	***
SPEEDLIMIT	-0.037489	0.021804	-1.719	0.085545	.
CURVELEVEL C	0.749625	0.944774	0.793	0.42752	
GRADELEVEL B	-0.005365	0.085409	-0.063	0.949913	
GRADELEVEL C	-0.127912	0.140205	-0.912	0.361599	
Average Speed	0.106216	0.032459	3.272	0.001067	**
Speed Variance	0.045824	0.011266	4.068	4.75E-05	***
THROUGH_LA	-0.211177	0.070738	-2.985	0.002833	**
Significant Code: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

Coefficient : the log relation between variables and crash rate.
P <0.05 means the influence of this factor is statistically significant.
P <0.001indicates the influence of this factor is statistically highly significant.

4.Model Implementation

- Regression Result (Cont'd)

  - speed variance and urban area have the highest significant influence on crash rates. Higher speed variance and roadways located in urban areas (P value<0.001) are more likely to have a higher crash risk.

  - Number of through lanes (P value<0.01) is also another important factor to crash risk. In theory, increasing through lanes (coefficient = -0.211177) will decrease the crash rate.

  - High average speed will increase crash rates.

5. Summary

For the first time, driving cycles are involved in predicting crash risk, as evidenced in this study. The main findings are summarized as follows:

- Freeway in urban area, fewer number of through lanes and high speed variance will increase crash risk.
- Though higher speed on full-access-control highways can reduce fuel consumption cost, it can also result in a higher crash risk.

Limitation:

- For traffic conditions, only LOS A is considered in this paper.
- In the negative binomial model, not all road features are covered because of limited data.

Thank you!

Suggestions and Questions?