

Casualty Actuarial Society  
Ratemaking and Product Management Seminar

# VEHICLE HISTORY

## Insurance scoring for your car

Michael K. Chen, FCAS  
Pinnacle Actuarial Resources, Inc.  
Tuesday, March 28, 2017

Donald F.J. Hendriks, ACAS, ASA  
CARFAX Banking & Insurance Group



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### CASUALTY ACTUARIAL SOCIETY

## Antitrust Notice



The Casualty Actuarial Society is committed to adhering strictly to the letter and spirit of the antitrust laws. Seminars conducted under the auspices of the CAS are designed solely to provide a forum for the expression of various points of view on topics described in the programs or agendas for such meetings.

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### CASUALTY ACTUARIAL SOCIETY

## Premium Leakage



In 2010...

- Rating error reduced premium revenue in the private passenger auto insurance industry by \$15.4 billion.
- Premium rating error represent[ed] 9.4% of a total \$164.1 billion in personal auto written premium.



Auto Insurance Industry "Donates" \$1.54 Billion: Premium leakage a significant hit to underwriting profit. Rep. N.p. Quality Planning, November 2011. Print.



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### Premium Loss by Rating Factor

Vehicle Rating Factor	Percent of Premium	Total Error Cost
Commute	1.03%	\$1.7 billion
Annual Mileage	0.87%	1.4 billion
Vehicle Usage	0.88%	1.4 billion
Vehicle Characteristics	0.30%	0.5 billion
Rated Territory	0.82%	1.4 billion
Vehicle Subtotal	3.90%	\$6.4 billion



Auto Insurance Industry "Donates" \$1.54 Billion: Premium leakage a significant hit to underwriting profit. Rep. N.p., Quality Planning, November 2011. Print.

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### Sources of Premium Leakage

Soft Fraud	Hard Fraud	Life Changes
<ul style="list-style-type: none"> <li>Incomplete information at quote</li> <li>Minor or unintentional inaccuracies on application</li> </ul>	<ul style="list-style-type: none"> <li>Hidden vehicle damage</li> <li>Undisclosed drivers</li> <li>Major, intentional misrepresentation on application</li> </ul>	<ul style="list-style-type: none"> <li>Graduation</li> <li>New job with new commute</li> <li>Marriage</li> <li>Kids in school</li> <li>Retirement</li> </ul>

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### Evolution of Auto Insurance Rating

Traditional Rating Plans	Modern Rating Plans
<b>Driver Classification</b> <ul style="list-style-type: none"> <li>Age, gender, marital status</li> <li>Driving records</li> </ul>	<b>Driver-Specific Data</b> <ul style="list-style-type: none"> <li>Credit History</li> <li>Driving Behavior (UBI)</li> </ul>
<b>Territory Classification</b> <ul style="list-style-type: none"> <li>Urbanity index</li> <li>Population density</li> </ul>	<b>Location-Specific Data</b> <ul style="list-style-type: none"> <li>Weather models</li> <li>Traffic density models</li> </ul>
<b>Vehicle Classification</b> <ul style="list-style-type: none"> <li>Model year</li> <li>Symbol</li> </ul>	<b>Vehicle-Specific Data</b> <p>???</p>

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What is vehicle history?

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- Damage information
- Mileage Data
- Ownership Data
- Title information
- Detailed service history

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Aging Vehicle Fleet

- Average age of fleet in 2016: 11.6 years
- New vehicles last longer than ever
  - More variance in drivability among vehicles of similar ages
  - More history per vehicle
- Age of vehicle isn't enough anymore

Vehicles Getting Older: Average Age of Light Cars and Trucks in U.S. Rises Again in 2016 to 11.6 Years. IHSOnlineNewsroom, 22 Nov. 2016.

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Polling Question 1:

Which vehicle would you want to insure?

A	B	C	D
2012 Ford Explorer XLT	2012 Ford Explorer XLT	2012 Ford Explorer	2012 Ford Explorer XLT
290HP V-6 FWD	290HP V-6 FWD	280HP V-6 FWD	290HP V-6 FWD
Symbol 18	Symbol 18	Symbol 18	Symbol 18
Value: \$15,592	Value: \$14,951	Value: \$7,247	Value: \$5,190

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**Polling Question 1:**

			
2012 Ford Explorer XLT 290HP V-6 FWD Symbol 18 Value: \$15,592	2012 Ford Explorer XLT 290HP V-6 FWD Symbol 18 Value: \$14, 951	2012 Ford Explorer 280HP V-6 FWD Symbol 18 Value: \$7,247	2012 Ford Explorer XLT 290HP V-6 FWD Symbol 18 Value: \$5,190

A picture is worth a thousand rating variables!




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**Same Vehicle, Different Risk**

			
2012 Ford Explorer XLT 290HP V-6 FWD Symbol 18 Value: \$15,592	2012 Ford Explorer XLT 290HP V-6 FWD Symbol 18 Value: \$14, 951	2012 Ford Explorer 280HP V-6 FWD Symbol 18 Value: \$7,247	2012 Ford Explorer XLT 290HP V-6 FWD Symbol 18 Value: \$5,190
<ul style="list-style-type: none"> <li>Odometer: 75,284</li> <li>1 owner</li> <li>Personal Use</li> <li>Complete service history</li> <li>Clean CARFAX report</li> </ul>	<ul style="list-style-type: none"> <li>Odometer: 62,863</li> <li>2 owners</li> <li>Registered for commercial use</li> <li>Some service records</li> <li>1 minor accident</li> </ul>	<ul style="list-style-type: none"> <li>Odometer: 192,926</li> <li>2 owners</li> <li>Formerly registered for police use</li> <li>No service records</li> <li>Body damage reported</li> </ul>	<ul style="list-style-type: none"> <li>Odometer: 261,336</li> <li>4 owners</li> <li>2 severe accidents</li> <li>Frame damage reported</li> <li>Stolen</li> <li>Salvage title</li> </ul>




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Vehicle History Data

**VERIFIED MILEAGE**




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### Annual Mileage as a Rating Variable

#### Study of auto insurance claims in Taiwan.

- Annual mileage:
  - Extremely powerful predictor of at-fault claims frequency.
  - Significance far exceeds that of *all other* variables
  - Complements information contained in other rating variables
- Rating system should include annual mileage and other variables:
  - Age
  - Territory
  - Claims history
  - Engine size

Lemaire, Jean, Songyong Park, and Kih-C. Wang. "The Use Of Annual Mileage As A Rating Variable." ASTIN Bulletin 46.01 (2015): 39-69. <http://www.actuaries.org/ASTIN/Colloquia/Hague/Papers/Lemaire.pdf>

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### Mileage in Rating is Nothing New

#### Robert Bailey and Leroy Simon:

- Canadian auto insurance data shows...
 

“...that certain available evidence supports the conclusion that annual mileage...is a very significant cause of unanalyzed variation among risks.”

Bailey, Robert A., and Leroy J. Simon. "Two Studies in Automobile Insurance Ratemaking." Proceedings of the CASXLVII Pt. 1 (1960).

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### Mileage as Rating Factor

#### ISO Study of over 450,000 insurance policies.

- Found significant difference in average claim costs between high and low annual mileage groups.
  - 0 to 3,000 miles per year: 44% fewer claims than average.
  - Over 20,000 miles per year: 28% more claims than average.
- Despite this, many carriers are *eliminating annual mileage* as a rating factor.

Gusman, Phil. "Use Of Mileage As Rating Factor Decreasing, But Accurate." PropertyCasualty 360 National Underwriter, 9 Apr. 2009. Web. <http://www.propertycasualty360.com/2009/04/09/use-of-mileage-as-rating-factor-decreasing-but-accurate>

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### Eliminating Mileage Rating Factors

- Internal studies find companies are better off *not using mileage* in their rating plans.
- Company responses include:
  - Stop using mileage altogether
  - Use broad, arbitrary mileage bands
  - Implement expensive UBI programs




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### Polling Question 2:

- How many miles do you drive in a year?
- A. 10,000 or less
  - B. 10,001 to 15,000
  - C. 15,000 to 20,000
  - D. More than 20,000
  - E. Don't know/Don't drive

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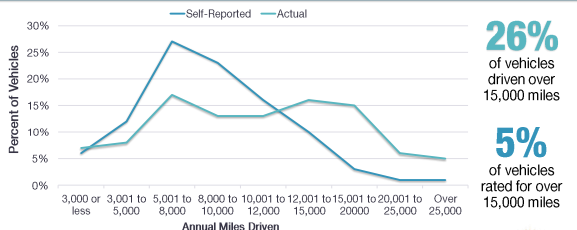
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### Self-Reported vs. Actual Miles




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### Polling Question 3:



The average light-duty vehicle in the U.S. was driven 11,443 miles in 2015\*.

**What is the average discrepancy between actual miles driven and miles used for rating personal auto insurance?**

- A. 2,500 miles
- B. 3,000 miles
- C. 4,500 miles
- D. 6,000 miles

\*U.S. Department of Transportation, Federal Highway Administration, 2015 National Household Travel Survey, Table VM-1.



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### Self-Reported Mileage



- Often Inaccurate
  - Customers may not know how much they drive
  - Significant cost incentive to underreport
  - Agents underreport to save time
- Can change over time
- Difficult for insurers to verify



Source: TransUnion Performance Analytics Database, 2006-2010



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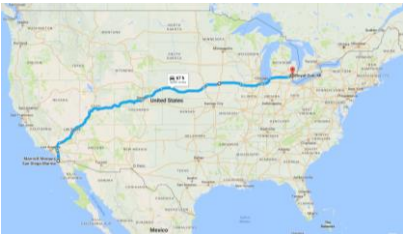
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### Average error is about 6,000 miles



Don's house  
to  
Marriott Marquis  
to  
Michael's house  
to  
Don's house

**4,690 miles**



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### How far is 6,000 miles?



Don's house  
to  
CARFAX HQ  
to  
Marriott Marquis  
to  
Michael's house  
to  
Don's house  
**5,545  
miles**

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### 6,000 miles is a long way!



Don's house  
to  
CARFAX HQ  
to  
Marriott Marquis  
to  
San Francisco  
to  
Michael's house  
to  
Don's house

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### Verified Annual Mileage

- Mileage reported by a third party
  - Departments of Motor Vehicles
  - Vendors
  - Software and apps
- Can be used in a more granular mileage rating plan
- Mileage already included in many rating plans
  - Conversion is (relatively) simple
  - Few regulatory concerns
- Often used in UBI to "slot" new insureds into appropriate initial UBI groups.

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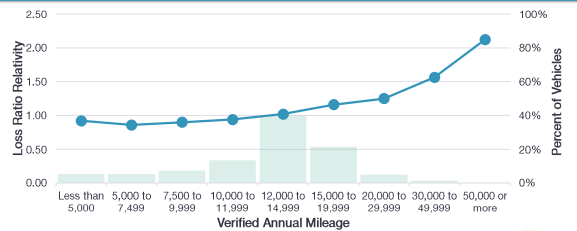
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**Lift from Verified Annual Mileage**



Source: TransUnion Performance Analytics Database, 2006-2010  
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Vehicle History Data  
**OWNERSHIP AND DAMAGE HISTORY**

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**Current Registration Type**

- Used as a means to verify vehicle use**
- Less likely to be fraudulently reported than self-reported use
    - Tax incentives for commercial registrations
    - Significant penalties for misreporting
  - Used in underwriting to match customers to most appropriate coverage

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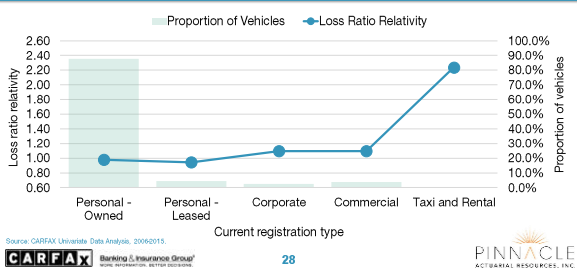
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### Lift from Current Registration Type




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### Ownership History

- Are one-owner cars better risks?
  - Higher market value
  - Less wear and tear
- Are certified pre-owned cars better risks?
  - Inspected by factory-trained technicians
  - Less wear and tear
  - Safety components under warranty



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### Length of Ownership

CARFAX studies show that the longer a car is owned, the better the risk becomes.

- Newer cars are less familiar.
- Newer cars are used on longer drives.
- Minor damage is less likely to be reported on older cars.
- Lemons get moved on to new owners.

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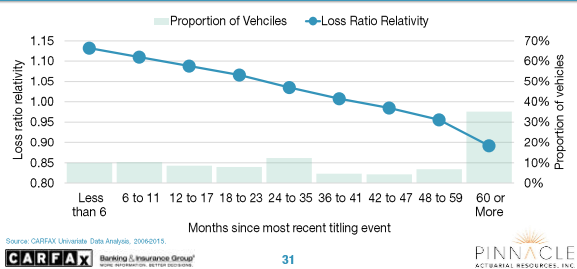
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### Lift from Length of Ownership




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### Severe Accidents



- Structural integrity is compromised
- Many sensitive parts may be improperly installed or remain unrepaired
- Low-quality aftermarket parts are prone to failure

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### Minor Accidents

- Repairs may be improperly or incompletely done
  - May cause sensitive electronics to fail
  - Damage to critical structural components may be missed
- Low-quality aftermarket safety components may fail



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**Flood Vehicles**

- Damage to ABS system
- Damage to electronic safety system sensors
- Damage to passive and active restraint systems
- Internal rust in critical structural or mechanical components



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**Branded titles**

**Salvage Titles**

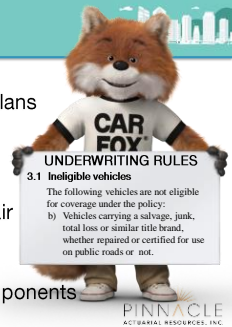
- Precluded by many underwriting plans
- Need copy of title

**Rebuilt Titles**

- Repairs may not meet standards
- Often incomplete or improper repair

**Fire and Flood Titles**

- Possible damage to sensitive electronic or critical structural components



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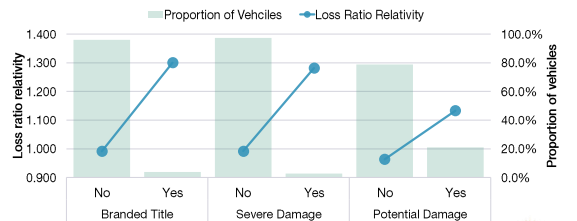
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**Lift from Vehicle Damage**



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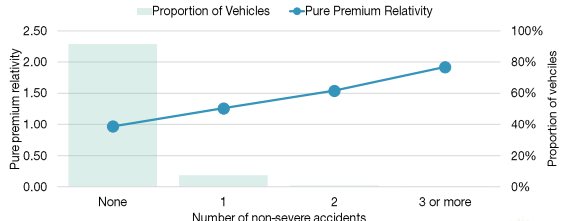
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**Lift from Non-Severe Accidents**



Source: TransUnion Performance Analytics Database, 2006-2010  
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Vehicle History Data  
**MULTIVARIATE ANALYSES**

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**Mileage and exiting variables**

Integrating verified mileage requires controlling for confounding variables

Strong Correlation	Some Correlation	Weak Correlation
<ul style="list-style-type: none"> <li>Driver Age</li> <li>Vehicle Type</li> <li>Length of Ownership</li> <li>Territory                             <ul style="list-style-type: none"> <li>Urbanity Index</li> <li>US Census Data</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Driver Gender</li> <li>Vehicle Age</li> <li>Marital Status</li> <li>Use Class</li> <li>Driver:Vehicle Ratio</li> </ul>	<ul style="list-style-type: none"> <li>Vehicle Symbol</li> <li>Credit-Based Insurance Score</li> <li>Self-reported Mileage</li> <li>Vehicle Value</li> </ul>

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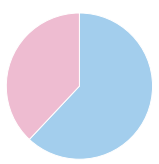
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**Average Miles by Gender and Age**

Age	Male	Female	Total
16-19	8,206	6,873	7,624
20-34	17,976	12,004	15,098
35-54	18,858	11,464	15,291
55-64	15,859	7,780	11,972
65+	10,304	4,785	7,646
<b>Average</b>	<b>16,550</b>	<b>10,142</b>	<b>13,476</b>



Data as of July 13, 2016

Source: U.S. Department of Transportation, Federal Highway Administration, 2009 National Household Travel Survey <http://nhts.omb.gov>



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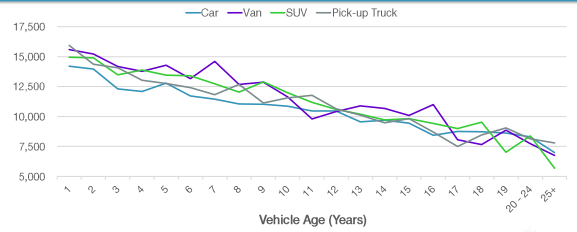
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**Average Annual Miles by Vehicle Age**



Source: U.S. Department of Transportation, Federal Highway Administration, 2009 National Household Travel Survey URL: <http://nhts.omb.gov>



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**Multivariate Analysis Using Individual Vehicle Data**

- Matched by VIN and report dates
- Include potentially correlated factors
  - Driver information
  - Vehicle characteristics
  - Policy details
  - Insurance score
- Multivariate analysis performed to determine value of vehicle history *beyond current rating plans*



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**Multivariate Analysis Using Individual Vehicle Data**

Current Policy Characteristics	Policy History Characteristics	Current Vehicle Characteristics
Age	Accidents	Symbol
Gender	Violations	Model year
Marital Status	Cancel / reinstatements	Vehicle characteristics
Number of drivers/operators	Prior limits	Anti-theft device
Insurance score	Prior insurance	Passive restraint
Multi-line		Anti-lock
Territory		Existing damage

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**Multivariate Analysis Using Individual Vehicle Data**

Severe Problems	Potential Damage	Ownership History
Title Brands	Non-severe Accidents	Number of Owners
Salvage	Frame Inspection	Type of Ownership
Flood	Failed Emissions	Length of Ownership
Fire	Failed Safety Inspection	Odometer History
Total Loss	CARFAX Flood Advisory	Average Mileage
Severe Accidents		Odometer Readings
Frame Damage		
Airbag Deployment		
Previously Stolen		

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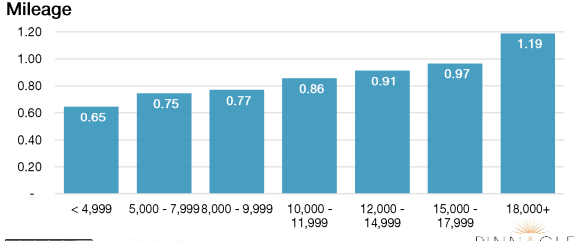
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**Multivariate Analysis Using Individual Vehicle Data**



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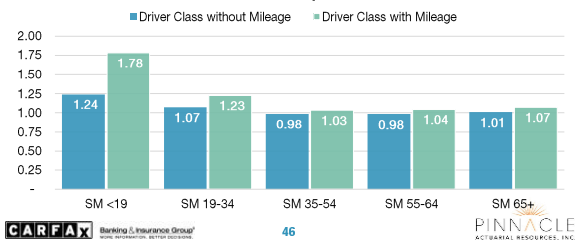
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Multivariate Analysis Using Individual Vehicle Data

Model Iterations: Driver Class Example




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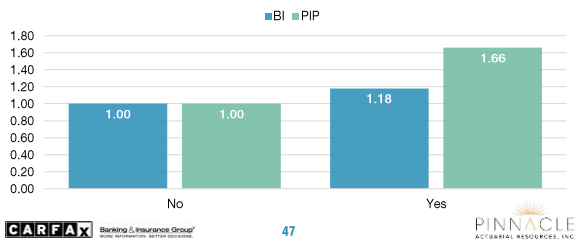
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Multivariate Analysis Using Individual Vehicle Data

Severe Problems: Branded Title




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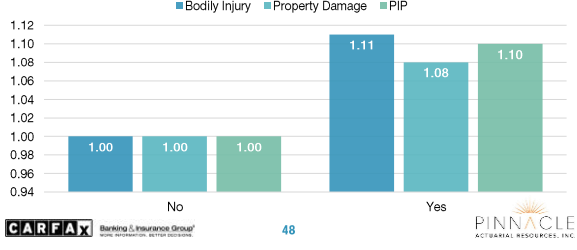
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Multivariate Analysis Using Individual Vehicle Data

Potential Damage




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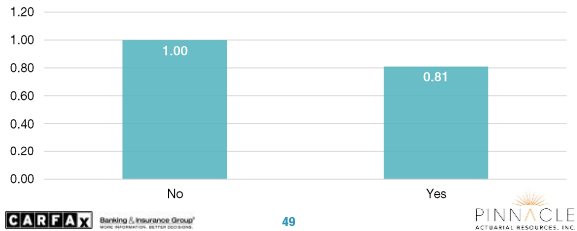
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Multivariate Analysis Using Individual Vehicle Data

Ownership Information: Certified Pre-Owned Vehicle




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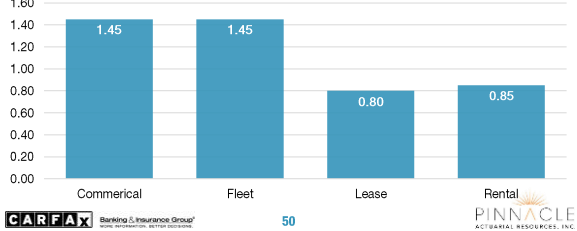
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Multivariate Analysis Using Individual Vehicle Data

Ownership Information: Prior Use




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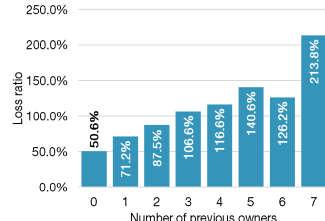
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Multivariate Analysis Using Individual Vehicle Data



- Loss ratio consistently higher as number of previous owners increases
- Worst performers are 3 times as bad as best performers

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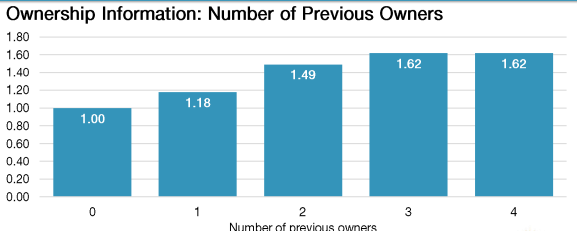
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Multivariate Analysis Using Individual Vehicle Data



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DATA INFORMATION: BEST OF 2012-2016

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