The Use of Annual Mileage as a Rating Variable

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Outline

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1. Traditional Rating in the US

- Age, sex, marital status of main driver
- Make and model of car
- Use of car
- Territory
- Claims and traffic violations history
- Annual mileage (7,500 miles only cut-off)

“Just have your car send us your driving habits”

- Optional program introduced in PA last May
- Uses On-Star Telematics
  - Factory-installed, all new GM cars
  - Professionally installed for $100
- Annual monitoring costs: $200
- Benefits: automatic crash response, emergency services, roadside assistance, stolen vehicle assistance. GPS + Hands-off calling for $100.
- Monthly e-mail of mileage to the Insurance company and policyholder
- Discounts at renewal: 32% (3,500 miles); 13% (11,000 miles); 5% (15,000 miles)
- Premium increase if policyholder found to exceed 7,500 miles

Other companies use:

- Breaking habits, driving between midnight and 4 am
- Speeds of 80 miles per hour
- Type of road travelled
- Ptolemus (2012) estimates that 2 million cars in Europe and the US use telematics-based rating

Insurers at a crossroads

- Traditionally, insurers have been reluctant to use mileage rating, as odometer tampering was not difficult
- Insurers use proxy variables instead
- Butler (2006) argues that 12 commonly used rating variables are proxies for mileage: sex, car age, previous accidents at-fault and not-at-faults accidents, credit score, zip code, income, military rank, existence of previous insurer, premiums by installments, years with employer, collision deductible, tort rights

Situation may change rapidly, due to telematics, GPS, tampering-resistant odometers, and the decreasing cost of these new technologies

2. Statistical Studies

- Lemaire (1985). 4,000 Belgian drivers, average annual km 15,344. Claim frequencies rise from 5.84% (< 5,000 km) to 10.44% (> 30,000 km)
- Ferreira and Minikel (2010). 2.87 million car years, MA. Increasing mileage from 10,000 to 30,000 raises claim frequency from 5% to 8%
- Litman (2011). 500,000 vehicles years, Vancouver. Claim frequencies increase from 4% (< 5,000 km) to 10% (> 35,000 km)
- **→Accident rates increase with mileage, but less than proportionately.**

Mileage Rating: A Controversial Issue

- PAYD: Pay-As-You-Drive
- Large literature, but not peer-reviewed.
- Mostly lobbying groups
- In favor of PAYD: environmental groups, associations representing females, seniors, low-income groups
- NOW: Females drive less than males (10,143 v. 16,553) but not rating difference after age 30
- Opposing PAYD: Oil industry, insurance industry (insurers would carry most of the costs, while most benefits are externalities).
- Bordoff(2008) estimates social benefits at $257 per vehicle, but only $34 insurer benefits

Self-reported mileage: on the way out

- At renewal, drivers provide mileage + sometimes photo of odometer. Random checks by insurer, or audits, for instance with annual inspection
- Clear conflict of interest for policyholder
- Some odometers can be tampered
- Mileage disregards other dangerous behavior
- No additional revenue through the sale of ancillary services

Telematics pricing: advantages

- More accurate
- Based on own behavior, not on a group
- Does not rely on age, gender, territory, variables that could become unlawful
- Individuals have more control over their price
- Subsidies across groups are reduced
- Uninsured driving may reduce
- Less fraud
- Incentive to improve driving skills, and to reduce mileage
- Reduced traffic, pollution, time wasted in jams
- Accident externalities: costs are reduced for everyone
- Shorter delay between improved driving and price decrease
- Numerous side benefits available

Telematics pricing: disadvantages

- Installation and monitoring costs
- Less predictable premiums
- Only used for discounts → decreased income
- Adverse selection possible, since optional
- System can be gamed
- Invasion of privacy
- Practical problems
- Regulatory hurdles

Taiwan

- 32,260 sq. km (the size of Belgium)
- $37,000 GDP per capita (equals Germany)
- Very high population and traffic density
- →only 4,675,000 cars. Few couples own two
- Data covers compulsory bodily injury liability, voluntary bodily injury + property damage
- Rating variables: use of car, gender, age
- Bonus-malus: 10 classes; premium levels 70, 80, 90, 100, 110, 120, 130, 140, 150, 160
- One-class discount if no claim, 3-class penalty per claim

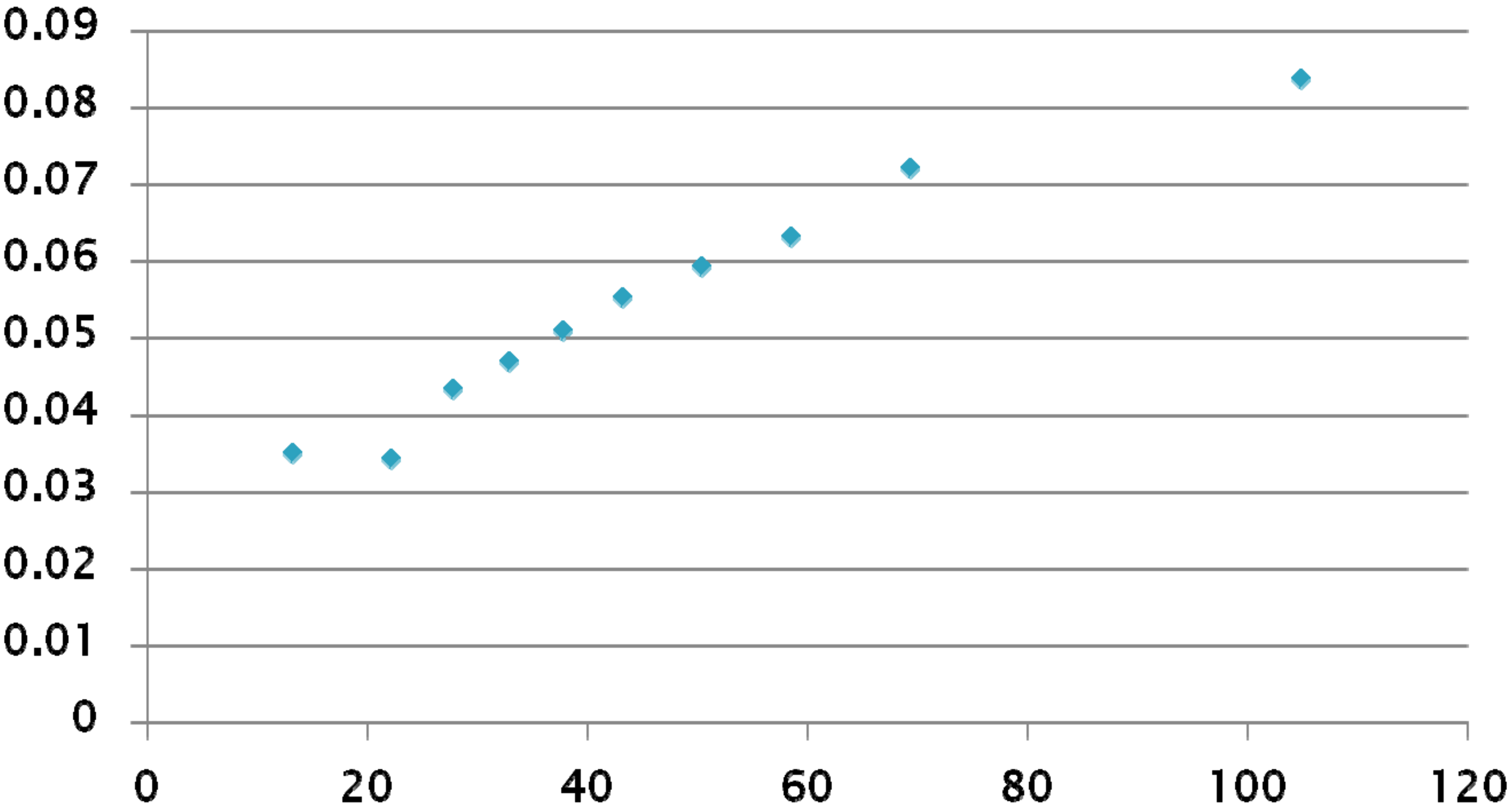
Data

- 0.25 million policy-years, from leading car manufacturer, insurer, and repair shops
- Policy years 2001 to 2007
- Dependent variable: number of claims
- Explanatory variables
  - Gender
  - Age
  - Vehicle type and use
  - Mileage (km per day)
  - Marital status
  - Car age
  - City / rural
  - Territory (north, south, central, east)
  - Engine cubic capacity

Claim frequencies for rating variables

Age group	Males	Females	All
< 30	0.0674	0.0652	0.0661
30–60	0.0473	0.0562	0.0537
> 60	0.0477	0.0523	0.0500
All	0.0493	0.0567	0.0545

Claim frequency as a function of daily km



Regression results

- Probit or Ordered Probit model
- $\text{Probit}(C_{it}) = \alpha + \beta_1 X_{it} + \beta_2 Y_{it} + \beta_3 BMS_{it} + \beta_4 Miles_{it} + \beta_5 D_{it} + \varepsilon_{it}$

Number of claims	Frequency
0	247,989
1	8,223
2	2,690
3	136
4	25
5	2

Model 1: Rating variables

Variable	Parameter estimate	Wald Chi-square	Pr > ChiSq
Age 30-60	-0.0735	21.61	< 0.0001
Age 60+	-0.0822	8.94	0.0028
Female	+0.0577	34.90	< 0.0001
Bonus-malus	+0.6183	311.39	< 0.0001

Model 2 – Rating variables + Mileage

Variable	Parameter estimate	Wald Chi-square	Pr > ChiSq
Age 30-60	-0.0539	11.50	0.0007
Age 60+	-0.0295	1.13	0.2875
Female	+0.0739	56.48	<0.0001
Bonus-malus	+0.5928	283.41	<0.0001
Mileage	+0.0424	756.34	<0.0001

Model 3: Classification variables

Variable	Parameter estimate	Wald Chi-square	Pr > ChiSq
Age 30-60	-0.0586	12.57	0.0004
Age 60+	-0.0614	4.77	0.0289
Female	+0.0459	21.47	< 0.0001
Bonus-malus	+0.0541	10.93	0.0009
Married	-0.0298	3.31	0.0689
Car age 0-1	+0.1856	69.69	< 0.0001
Car age 1-2	+0.0724	13.86	0.0002
Car age 2-3	+0.0198	0.99	0.3198
Car age 3-4	+0.0272	1.65	0.1986
Car age 4+	-0.0033	0.02	0.8883

Model 3 – continued

Variable	Parameter estimate	Wald Chi-square	Pr > ChiSq
Engine capacity 2	–0.0564	31.41	<0.0001
Engine capacity 3	–0.0606	8.61	0.0033
City	–0.0073	0.64	0.4222
North	–0.0720	12.61	0.0004
South	–0.0323	2.52	0.1127
Middle	–0.0183	0.70	0.4018

Model 4: All variables

Variable	Parameter estimate	Wald Chi-square	Pr > ChiSq
Age 30-60	-0.0366	4.85	0.0276
Age 60+	-0.0048	0.03	0.8641
Female	+0.0621	38.82	< 0.0001
Bonus-malus	+0.1546	8.16	0.0043
Mileage	+0.0436	783.32	<0.0001
Married	-0.0320	3.76	0.0524
Car age 0-1	+0.1852	68.86	< 0.0001
Car age 1-2	+0.0650	11.06	0.0009
Car age 2-3	+0.0150	0.56	0.4526
Car age 3-4	+0.0232	1.19	0.2751
Car age 4+	-0.0046	0.04	0.8444

Model 4 – continued

Variable	Parameter estimate	Wald Chi-square	Pr > ChiSq
Engine capacity 2	−0.0758	55.99	<0.0001
Engine capacity 3	−0.0752	13.09	0.0003
City	+0.0214	5.37	0.0204
North	−0.0713	12.26	0.0005
South	−0.0347	2.89	0.0890
Middle	−0.0146	0.44	0.5053

Impact on Bonus-Malus System

- A huge literature deals with bonus-malus design … independently of other variables
- which creates a potential double-counting problem
- Authors seems to be aware of the problem
- “The use of more *a priori* classification variables is expected in free market countries, which decreases the need for a sophisticated BMS”
- Adverse selection and insurer’s lack of knowledge of driving behavior is often cited as main reasons to introduce BMS, with annual mileage frequently as main example
- But did not model it, until Taylor (1997)

Taylor's model

- Complicated Bayesian model, but simple simulation
- Unfortunately, Taylor has no access to real data, so made-up example
- Nine-class BMS
- Due to unspecified *a priori* variables, portfolio subdivided in ten rating classes

Taylor example. Portfolio structure

Risk Group	Mean cell claim frequency	Within-cell coefficient of variation
1	6.5%	0.75
2	8.9%	0.65
3	11.4%	0.60
4	13.7%	0.55
5	16.1%	0.50
6	20.1%	0.45
7	24.9%	0.40
8	29.7%	0.40
9	36.0%	0.40
10	50.5%	0.40
Average	15.7%	

Taylor example. Simulation results

BMS Class	Stationary %	Raw claim frequency	Expected claim frequency	Ratio "raw / expected"
1	66	12	14	85
2	9	17	17	102
3	10	18	17	103
4	4	21	19	111
5	4	23	20	116
6	3	30	22	139
7	2	32	22	145
8	1	38	24	156
9	1	46	26	175

Taylor example: Recommended BMS premium levels

BMS Class	Premium ignoring covariates	Premium recognizing covariates
1	40	61
2	57	73
3	59	74
4	71	80
5	77	83
6	100	100
7	107	104
8	125	112
9	152	126

Taiwan example: 10 mileage classes

Mileage class (km/day)	Mean cell claim frequency	Within-cell coefficient of variation
0 – 19.02	0.0351	6.3532
19.02 – 25.24	0.0346	6.3280
25.24 – 30.44	0.0434	5.6873
30.44 – 35.27	0.0470	5.4044
35.27 – 40.32	0.0511	5.2349
40.32 – 46.13	0.0554	5.0129
46.13 – 54.73	0.0593	4.8487
54.73 – 62.22	0.0632	4.7046
62.22 – 76.42	0.0721	4.3980
76.42+	0.0838	4.1553
Average: 44.29	0.0545	5.0813

Stationary distribution of policyholders

Miles	BMS 1	BMS 2	BMS 3	BMS 4	BMS 5	BMS 6	BMS 7	BMS 8	BMS 9	BMS 10
1	.932	.009	.010	.012	.005	.006	.006	.006	.010	.015
2	.919	.008	.011	.012	.004	.005	.006	.005	.008	.013
3	.908	.008	.012	.014	.007	.008	.008	.007	.012	.019
4	.886	.011	.015	.019	.006	.007	.009	.009	.013	.019
5	.893	.013	.016	.017	.007	.009	.007	.011	.013	.022
6	.870	.012	.016	.016	.010	.010	.010	.009	.015	.026
7	.878	.013	.016	.017	.008	.009	.012	.010	.014	.024
8	.857	.014	.017	.021	.008	.011	.011	.013	.017	.028
9	.851	.016	.018	.025	.008	.011	.011	.012	.020	.032
10	.824	.019	.214	.023	.011	.013	.012	.014	.020	.035
All	.882	.012	.015	.018	.007	.009	.009	.010	.014	.023

Taiwan example. Simulation results

BMS Class	Stationary %	Raw claim frequency	Expected claim frequency	Ratio “raw / expected”
1	88.19%	1.43%	5.40%	26.40%
2	1.25%	12.36%	5.82%	212.36%
3	1.52%	11.47%	5.76%	199.13%
4	1.77%	16.54%	5.77%	286.73%
5	0.75%	20.78%	5.80%	358.23%
6	0.90%	27.60%	5.83%	473.38%
7	0.92%	35.01%	5.79%	604.58%
8	0.97%	41.13%	5.84%	704.35%
9	1.42%	51.58%	5.83%	884.79%
10	2.33%	72.77%	5.88%	1237.59%

Taiwan example: Recommended BMS premium levels

BMS Class	Current BMS level	Premium ignoring covariates	Premium recognizing covariates
1	70	8.62%	9.21%
2	80	74.71%	74.06%
3	90	69.33%	69.45%
4	100	100.00%	100.00%
5	110	125.59%	124.94%
6	120	166.81%	165.09%
7	130	211.59%	210.85%
8	140	248.63%	245.65%
9	150	311.79%	308.58%
10	160	439.85%	431.62%

Conclusions

- Annual mileage appears to be, by far, the most important rating variable
- Bonus-malus remains a very important component in auto insurance pricing
- Making the bonus-malus system tougher would improve its rating accuracy
- Mileage and bonus-malus should be the building blocks of rating
- Other variables (age, car age, engine cubic capacity, and some territories) could be added, at the price of a complicated system