DRIVER NEGLIGENCE VS. ODOMETER MILES:[†] RIVAL THEORIES TO EXPLAIN 12 PREDICTORS OF AUTO INSURANCE CLAIMS

Patrick Butler*

Presented at the American Risk & Insurance Association Annual Meeting

Washington, D.C., August 9, 2006

"For a successful technology, reality must take precedence over public relations, for nature cannot be fooled." Richard P. Feynman.

I. Introduction

I.1. Overview

This paper challenges accepted explanations for well-established correlations. The correlations allow insurers to assign cars to groups that predict accident and claim frequencies per 100 insured car years.[1] Correlations with driver age and regional geography can be explained by variations in accident involvements per million miles established by engineering studies[2] and are not considered in this research. Instead this paper examines a dozen predictor variables that have no obvious connection to physical risk. Previous studies focus on one or two predictors. For example, driver sex is used by Brockett, Golden, and Dunn (2005) as a benchmark predictor in seeking to explain why lower credit scores predict higher accident frequencies. My research includes these two predictors—driver sex and credit score—with 10 others to test rival theories for their ability to provide causal explanations and avoid conflict with established economic theory.

I.2. Rival Theories

Since most automobile accidents are caused by one or more negligent acts, the prevailing theory for the correlations is that they are proxy measures of *driver*

---

† In law and economics terminology this rivalry might be called "care level vs. activity level."

* National Organization for Women, Washington, D.C.; pbutler@centspermilenow.org

1. This definition conforms to actuarial convention, as in the textbook "Foundations of Casualty Actuarial Sciences," Casualty Actuarial Society (2001). Scaling frequency to aggregates of 100, or even 1,000 car years, has the advantage of emphasizing that a stable frequency is property of an even larger, well-defined group of cars. Although academic literature often refers to frequency on the numerically equivalent per-car-year basis, this convention tends to imply incorrectly that an accident or claim frequency per car year is a measurable property of individual cars, rather than being a measurable property of a large group of cars.

2. The strong variation with driver age of accident involvements per million miles is graphed by Williams (1999). The effects of different road types in rural and urban settings on fatalities per billion kms is summarized by Evans (1999:78). The range from lowest to highest in both kinds of distance rates is about 10 times.

negligence. The presumption is that variation in the amount of driver negligence explains correlations with claim frequencies.[3] If the drivers of a group of cars on average commit fewer negligent acts, then the group will produce less annual risk and fewer claims than other groups of cars. In order to accurately deter negligence Posner (2003:201) explains that liability premiums ideally should be closely related to differences in driver negligence.

> Although the [current] premiums are not uniform, the differences frequently reflect criteria . . . that are only loosely related to negligence. . . . [T]he method of calculating liability insurance rates overdeters some drivers and underdeters others.[4]
>
> If the liability insurance market were not regulated, insurance companies might charge different premiums to their customers keyed more closely to differences in the probability that a customer would, through his negligence, injure someone in an accident.

This attribution of differences in probability of accidents to differences in driver negligence, however, entails conflicts between economic theory and insurance fact. A key observation is that the cars of financially stressed groups consistently seem to produce the most liability (and other) claims per 100 car years. Consequently, insurers charge these groups the highest prices, which makes compliance with mandatory insurance even more difficult for groups who in theory should be if anything more risk averse and less negligent than average. This and other conflicts invite alternatives to the driver negligence theory.

The theory proposed by this paper to explain variations in claim frequency is that each of the 12 predictor variables is a proxy for *average odometer miles.* The more odometer miles per car year a group averages, the more accidents and claims per 100 car years the group produces. Since each mile a car travels has a chance of accident, each mile traveled produces a brand new cost.[5] Each mile an insured car travels transfers a measurable risk and its cost to the car's insurance pool. Even though during a year a large majority of cars in an insurance pool are accident-free, they all produce the total risk that is statistically realized by the few that have the pool's accidents.[6] Therefore, a pool's claims are the inescapable realization of the risk transferred by every mile driven by *all* of the cars in the pool. For the sake of tying premiums to cost as it is occasioned, logically every odometer mile driven must count in paying for the insurance costs of road accidents.[7]

---

3. This association is the basis of negligence law's purpose to deter negligence and so to reduce driving risk and prevent (statistically) some accidents from occurring. The negligence theory of tort law therefore assumes that drivers suitably deterred can reasonably reduce their negligent acts.

4. Exactly what it is that premium rates charged on a per-car basis are capable of over- and under-deterring is discussed in Section III on the odometer-mile theory.

5. Production of this cost is as real as the mile-by-odometer-mile production of water vapor, carbon dioxide, and other exhaust products.

6. If fewer miles of risk are transferred to an insurance pool of cars, as happens whenever unemployment or gasoline prices rise sharply, the number of claims the pool experiences per 100 car years decreases more or less accordingly. (With a rise in unemployment, fatal accidents appear to decrease more than odometer miles do because discretionary nighttime driving to entertainment and restaurants is preferentially reduced relative to daytime driving.)

7. For commercial fleets, an audited odometer mile premium basis has always been an option to the vehicle year unit as the basis for calculating and paying premiums. Miles are paid for

Under both theories—driver negligence and odometer miles—the explanations apply to pools and not to individual cars. It should be understood that although a pool of cars grouped by a particular value of a variable may produce 50% more claims per 100 car years[8] than cars grouped by another value of the variable, the very large majority of cars with each value will not produce a claim during a year. For example, if a subpool of new cars produces 6 liability claims per 100 car years in comparison to a matching subpool of old cars that produces 4 liability claims per 100 car years, this means that slightly more than 94 per 100 new cars[9] compared with slightly more than 96 per 100 old cars will produce no liability claim during the year. Nearly all of the individual new and old cars had the identical claim-free record.

Another general consideration is that each theory to explain variations in predictor group claim frequencies per 100 car years posits the existence of a single causal variable—either average driver negligence or average odometer miles—that is proxied by each of the 12 predictive variables insurers use. Therefore, the effects of the multiple variables in predicting the single claim frequency variable will overlap. To avoid the overlap and the double counting of the effects of different claim frequency predictor variables ("risk factors"), Miller and Smith (2003) describe the use of multivariate analysis. They rank the individual predictors for strength, but do not adjust for the different degrees to which individual companies actually use each variable. For example they use model year and driver sex as though insurers used these variables for all cars they

---

in advance at a pre-established cents-per-mile rate. At the end of the policy period insurers audit odometers and adjust the final charge or credit accordingly.

For private passenger cars an efficient odometer-mile insurance system would require odometer audits no more than once a year (mainly for totaling the miles driven by all of the cars in a pool during a time period in order to convert the total cost of the pool's claims incurred during the period to a cents-per-mile basis) and in verifying coverage for claim settlement. Car owners would purchase miles of insurance in advance at the going cents-per-odometer-mile rate for the car's class and driving coverages in amounts to suit individual needs and budgets. The miles purchased would be added to the odometer reading and recorded, along with the policy period, on the car's proof of insurance card. The owner would be responsible for buying more miles before the odometer limit was reached and coverage lapsed. (Exceeding the odometer limit and odometer tampering are standard coverage termination provisions in mechanical breakdown insurance contracts.) Comparisons with the current car-year system of transaction efficiency, suspension of premiums while cars are not in service, fraud control, and mandatory insurance enforcement are contained in two reports: Butler (1993a) and Butler (2000).

Although every car in use is already fully equipped to start using odometer-mile insurance, some insurers have recently tested installing global-positioning-satellite (GPS) systems on cars for recording miles (or minutes), location, and time of travel. At the outset of one test, Butler (2000, pp. 27-28) identified statistical credibility problems owing to the proliferation of the time of day and location data cells (some of which would either have too few claims for predictability or even be empty), noted the expense of equipment and installation and the administrative expense of *ex post* monthly billing for completed travel, suggested privacy concerns, and predicted failure, which occurred within two years.

8. That is, under the negligence theory the cars of one group have drivers who are 50% more negligent than the drivers of the other group, and under the odometer miles theory the cars of one group are driven 50% more miles on average than the cars of the other group, say 15,000 odometer miles versus 10,000 odometer miles per car year.

9. Because most accident-involved cars are shortly returned to the road or replaced, a predictably small proportion of these cars will be involved in a second, or even a third claim. This means that at a given claim frequency per 100 car years, slightly more cars in the pool will be claim-free than just the complementary proportion to the claim frequency.

cover. As noted in the discussions that follow, for marketing and other compelling reasons, companies do not use available predictors consistently across all of the cars they insure.[10]

I.3. Two Terms: Risk Type and Negligence

While the legal literature attributes variation in accident frequency among groups to differences in driver negligence (the term adopted by this analysis owing to its legal meaning), the insurance economics literature rarely cites differences in negligence and instead posits different driver risk types to explain differences in claim frequency. Nevertheless, these two terms appear to be functionally equivalent because they share important characteristics.

An important equivalence is that both terms are almost invariably applied only to at-fault accident involvements and liability claims. To be deemed at-fault in an accident a driver must have been found to be legally negligent in court or by claims adjusters. In the insurance literature, differences in claim frequencies among groups are described in categorical terms that distinguish two types of drivers. These types are variously designated by different authors as low- and high-cost drivers, low- and high-risk drivers, and good and bad drivers. These categories match the legal literature's binary categorization of accident involvement as at-fault and not-at-fault, or directly as negligent and non-negligent.

Finally, although the terms driver risk type and driver negligence are explicitly referring to differences in driver behavior, both actually denominate insurance data that are car-based, such as a particular claim frequency per 100 car years. In fact, the traditional uniform use by all private passenger car insurers of the car-year (exposure) unit as the basis for costs and prices contrasts strongly with the variability among insurers and over time in their use of driver characteristics—complicated combinations of age, sex, marital status, occupation, education, driving history, and credit history—in the definitions of each insurer's categorization of the cars it insures. The differences in claim frequencies that correlate with these driver (and other) categories are what driver negligence, or driver risk type, theory seeks to explain.

II. Explanations Based on Driver Negligence Theory

Table 1 lists the 12 predictive variables and shows where the alternative *Driver-Negligence* and *Average-Odometer-Miles* explanations for them apply. Explanations based on driver negligence will be considered first. To explain why predictive variables work, the driver negligence theory assumes broad variations in driver negligence or risk type across groups of cars, column DN-1 in Table 1.

---

10. Predictive characteristics of insureds that are known to insurers but are ignored in pricing annuities are studied by Finkelstein and Poterba (2006). The authors also cite instances in automobile insurance and aptly name the phenomenon "unused observables," but puzzle over insurers' reasons for ignoring some available risk-predictive information.

TABLE 1. ***Two Explanations Applied to 12 Predictor Variables***

GROUP	CORRELATION	PREDICTOR VARIABLE of Claim Frequency per 100 Car Years - (Where binary, the higher frequency value is shown)	EXPLANATORY THEORIES					
			BASED ON DRIVER NEGLIGENCE (DN)			BASED ON AVERAGE ODOMETER MILES (AOM)		
				Private Information on driver negligence				
			The variable proxies for the pool average Driver Negli-gence	**Company** learns about & **selects** the cars of high negligence drivers out of pools	Owners (but not companies) know the negligence of the cars' drivers & **self select** a new company or coverage amount accordingly*	**The variable proxies** for the pool average Odometer Miles	**Self Selection** by owners of >avg-miles cars or <avg-miles cars into or out of pools as **Demand-Law responses to per-car price structure** (Table 5 shows the four possibilities)	**Risk Aversion** by car owners
			DN-1	DN-2	DN-3	AOM-1	AOM-2	AOM-3
A	+	Driver sex - Man	X			X		
"	–	Car age	X			X		
B	+	AF accidents	X			X		
"	+	NAF accidents	X			X		
C	–	Credit score	X			X	X	
"	–	Zip code average income	X			X	X	
"	–	Military rank	X			X	X	
D	+	Prior insurer? - No	X			X	X	
"	+	Pay by Installment? - Yes	X			X	X	
E	–	Years with Company	X	X**	X**	X	X	
F	–	Collision deductible	X		X	X	X	X
"	+	Pa. Tort Rights - Full	X		X	X	X	X

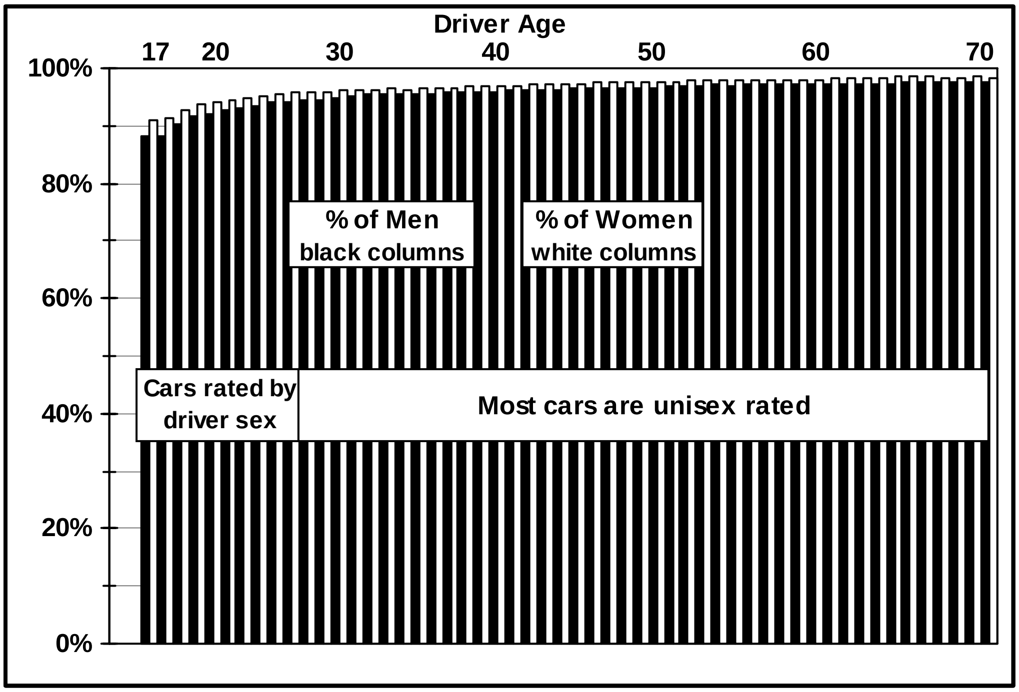
"X" indicates that the theory is, or will be, applied to the correlation. Multiple theories ("X" "X") unless otherwise noted apply in combination to explain the correlation.
* Previous studies either call this "adverse selection" when drivers that know they are more negligent than average as a consequence choose the greater-coverage options (smaller deductible and full-tort), or call it "moral hazard" when the drivers of average negligence that choose greater-coverage options as a consequence drive more negligently than average.
** These are alternative explanations, rather than being complementary.

II.1. Driver Sex

Whenever insurers classify cars by driver sex—which traditionally is done for about one in four cars, mainly in households with young drivers—the cars assigned to the man-driver categories produce more claims per 100 car years than the cars assigned to the woman-driver categories. State reported accident involvements show the annual difference between men and women drivers, not just for young drivers, but for drivers in each age group, Figure 1. The rapid rise with age for young drivers in percent accident-free is the same for women and men. The question is why at each age the percent of women and men drivers annually not involved in a reported accident shows a small offset. But to insurers, it is the complementary percent accident-involved drivers that is the significant value: men drivers' involvements exceed women drivers' by 25% (for younger drivers) to 65% (for older adults). In explaining driver sex as a predictive variable, the question is why at all driver ages men have a greater annual accident involvement than women do.

The prevailing academic explanation for the difference between men and women drivers relates it to biological and behavioral differences. In their

FIGURE 1. ***Texas Drivers With <u>No</u> State-Reported Accident in 1999.***



investigation of causal links between accident frequencies and credit scores, Brockett et al. (2005) review studies of links between accidents and driver sex. The authors summarize ties to men's greater risky behavior.

> It has been well established that high testosterone levels in men influence their behavior. However, there is no single biological factor that influences sensation seeking behavior; rather, it is the combination and interaction of multiple genetically determined biochemicals that cause this personality characteristic. For example, the psychobehavioral characteristics of risk-taking are related to impulsivity, sensation seeking, aggression, and sociability with men engaging in more overall risky behavior than women. [page 12]

One variable the review does not discuss, however, is that evaluating differences in accident frequencies between groups from a risk producing activity must take account of group differences in the amount of the activity. The reference above to "men engaging in more overall risky behavior than women" must be intended to mean more than men merely doing more driving than women. This comparing of risky behaviors must be intended to mean that when men are driving, they take more chances per mile than women do, such as driving a greater proportion of their miles using cell phones or at speeds exceeding the speed limit. Either behavior if being engaged in when an accident occurs is usually taken as legal evidence of driver negligence.

II.2. Car Age

Next is car age, Table 1. Although the drivers of newer cars produce more *liability* claims per 100 car years than drivers of older cars,[11] the correlation is ignored in setting insurance prices, as McNamara (1987) explains:

> [A 1964 industry study showed] . . . that newer automobiles had a higher frequency of accidents leading to liability claims than the frequency associated with older automobiles. This fact was not reflected in the rating system because no reasonable relationship between the age of the automobiles and the likelihood of an accident leading to a liability claim could be established.

In addition to being unable to establish a reason for the negative correlation of car age with the frequency of at-fault accidents, McNamara concludes generally that "even proponents of statistics as the basic justification of relativities among classes must recognize that the use of statistics should be leavened with a liberal dose of common sense." Common sense in fact also underlies Pinquet's (1999:76) different explanation for why the prices of French insurers ignore the decrease in liability claim frequency with car age:

> Actual tariff structures never give to the age of the car the influence measured by statistical analysis. Insurance companies lose money with recent cars, while older ones are profitable. This discrepancy between risks and premiums can be explained by the fact that policyholders do not want their premiums to vary *abruptly*. [emphasis added.]

But why this constitutes common sense must be made perfectly clear: If insurers followed statistics and reduced liability premiums with car age, they would be unable to explain why a premium *abruptly increases* when an old car is traded for a new one. How can there be an increase in driver negligence if there is no change in drivers? This question presents a formidable challenge to a driver negligence explanation for the negative correlation of liability claim frequency with car-age.[12]

II.3. At-Fault (AF) Accidents

In general, if the cars of drivers who have produced a liability claim in the past three years are separated from a main pool that produces, for example, 5 liability claims per 100 car-years, in the following year the sub-pool of these cars produces 7.5 liability claims per 100 cars, 50% more than the overall average. Also, as a consequence of such sorting, the claim frequency of the large claim-free pool decreases about 7%.[13]

---

11. Collision claim frequencies also decrease with car age, as Bickerstaff (1972:80) states: "It is a well documented phenomenon that absolute [collision] claim frequency decreases as insured vehicles advance from one age group to another." From cars age one to age four the decrease in claims per 100 car years is 38% (data on page 90).

12. If this correlation ever became a political issue, in principle owing to the overlapping effects of the multiple predictor variables available, insurers could use the other variables to nullify the statistics showing the car-age correlation.

13. Calculated from a model, Butler and Butler (1989). In practice, Walters (1981:16) observes that little can be saved through "rating by past accident record in auto insurance where accident-free or claim-free drivers usually save at most five percent over the cost of not having

The presumed explanation under driver negligence theory is that at-fault accidents over time will sort the cars whose drivers are more negligent than average from insurance pools into sub-pools. These sub-pools will produce more liability claims in the future than the main pool of cars in the same class that have not recently produced a liability claim.[14]

The theory maintains that financial liability for negligently causing an accident creates an incentive for drivers to be non-negligent. Allowing insurance against this liability risk at one time prompted concern that it would eliminate this deterrent to negligent driving. But the concern has been assumed to be resolved by the insurance practice of increasing premiums for the cars of drivers whose negligence has occasioned liability claims. Posner (2003:201) explains that owing to this arrangement "the cost of an accident to the negligent injurer is no longer the victim's loss; it is the present value of any premium increase that the injurer may experience as a result of being found negligent."

Schwartz (2000:643) explains how tying liability insurance to driver negligence is supposed to promote corrective justice for non-faulty victims.

> Keeping in mind that in the tort system almost all liability is filtered through liability insurance, one can ask how that system can succeed in promoting corrective justice. It does so by providing compensation to accident victims out of an insurance pool which itself is financed by charges on all motorists, and which varies the amount of those charges by taking into account the individual's negligent driving record and the negligent driving characteristics of the groups to which the individual belongs.

Schwartz (2000:643) next explains how liability insurance is supposed to serve as a deterrent to negligence.

> Given the intermediation of liability insurance, how might it be that the tort system reduces bad driving? The explanation might be that motorists, concerned about the prospect of insurance premium increases, seek to avoid faulty accidents and faulty driving that might lead to code violations.

Negligence theorists, however, do not suggest the amount of premium increase for faulty accidents as suitable deterrent but by default and without comment leave it to auto insurers to base the surcharge on the approximately 50% increase in claim frequency they experience. Moreover, the theorists do not take into consideration the fact that insurers where permitted also increase premiums based on non-faulty involvement in accidents in which the driver of the insured car was not a negligent injurer but a victim.[15]

---

such a program." This statement takes into account that consumers are often told they are getting 10% to 20% discounts—as a consequence of price competition or regulatory mandates—but these administered discounts are accomplished by first raising the base rate for the purpose. Customers with smaller discounts, as well as those without a discount, are actually paying more than they would if there were no discount program, as Butler and Butler document.

14. Abbring et al. (2003, p. 799) express this conventional idea as: "an insuree with a large number of past claims is likely to be a bad driver and therefore to have a high future claim intensity."

15. Posner (2003:201) takes parenthetical and apparently disapproving note of this practice in stating that premium differences "frequently reflect criteria, such as accident involvement (*whether or not the insured was negligent*) . . . that are only loosely related to negligence." Emphasis is added.

II.4. Not-At-Fault (NAF) Accidents

The cars whose drivers in the last three years have been involved but NAF in an accident—and who may or may not have filed a liability claim against another car's insurer or an Uninsured Motor Vehicle (UMV) claim against their own car's insurer—as a sub-pool of cars produces about 50% more claims (of all kinds) per 100 car-years the following year than the main pool of accident-free cars from which they were separated. Also, as a consequence of such sorting, the claim frequency of the large claim-free pool decreases about 7%.[16]

Because the accident-involved drivers have been judged non-negligent, whenever insurers price on this correlation it can become a political issue. In response to a Congressional inquiry into such auto insurance practices, insurers submitted an insurance company letter which was sent to an attorney representing an insured surcharged following a not-at-fault accident. As justification the letter cites the results of a large study by the industry six years earlier. U.S. Congress, 1967 (p.82).

> "It was established beyond the shadow of a doubt that the individual who is involved in automobile accidents, regardless of whether he appears to cause them or not, is much more likely[17] to have accidents in the future than is the person who is accident free. . . . [I]nvolvement in an accident, regardless of who was at fault, was the important consideration."

On the basis of French experience, Pinquet (1998) points out that NAF accidents are equally predictive as AF accidents and argues for their use in pricing. Lemaire (1985, 1997) describes the same correlations from the 1970s experience of a Belgian insurer. Just behind at-fault liability claims as the strongest predictor of claim frequencies per 100 car years is "the number of accidents where the driver is not at fault." One of the explanations Lemaire offers is that "some drivers create a situation where an accident is likely to happen, even when they are not liable."[18]

A problem for this explanation, however, is that in order for the owner and occupants of the NAF driver's car to have claims against the insurer of the AF driver's car, or to have UMV claims against the car's own insurer, the car's driver must be entirely or mainly NAF. Any creating a "situation where an accident is likely to happen" would bar both kinds of claims under a state legal regime of Contributory Negligence, or reduce the claim amount under the increasingly prevalent state Comparative Negligence regimes. Owing to the adversarial

16. Calculated from a model that approximates auto insurance experience, Butler and Butler (1989).

17. The phrase "much more likely" to have accidents in the future means about 50% more likely and is strictly from the insurers' perspective on annual accident frequencies per 100 cars for sub-groups. Under the average odometer miles theory discussed below, an individual's chance of a future accident is unaffected by their accident record.

18. Insurers cite cost justification for increasing the prices of coverages for cars hit from behind while stopped at a red light, which can hardly be called creating a "situation where an accident is likely to happen" as Lemaire suggests in the text above. However, in conversation some scholars will not even concede this point and instead suggest that the car in front may have stopped too abruptly when the light was turning red—a basis insurers do occasionally use for refusing to pay a third party liability claim. The other explanation Lemaire offers is considered below in Part III's discussion of NAF accident involvements.

character of liability claims settlement, occasions when drivers actually cause accidents to happen but are still held NAF probably are not common. Therefore, the success of NAF accident involvement as a group predictor of higher future claim frequencies per 100 insured cars remains a major problem for the driver-negligence explanation.

Schwartz (2000:644) also considers the possibility that auto insurers increase premiums following first-party ("no-fault") claims for medical expense and income replacement when the driver of the insured car was not-at-fault. He sets out the problem in terms of the driver negligence theory of prediction:

> Take an accident in which C is driving properly through an intersection, and C's car is hit by D's car, which is running a red light. C files a no-fault claim, and collects from his no-fault insurer. . . . Given the circumstances of the accident, *there is nothing that is predictive* of C's exposure to accidents in the future. Absent that prediction, there is no rational basis for a premium increase. [emphasis added.]

Although there may be no rational basis in terms of negligence theory for a premium increase for victim C, there is a factual basis for an increase that is just as cost justified for victim C's car as it is for injurer D's car. Sub-pools of cars separately representing injurer and victim situations both subsequently produce more claims per 100 car years than the accident-free cars of their main pools.[19] Theoretical problems aside, there is no factual doubt that in using accident involvement to predict increased claim frequency, *negligence is predictively irrelevant*.

II.5. Credit-Based Score

Auto insurance claims per 100 insured car years increase almost linearly with the decrease in credit-based insurance scores of car owners. In an industry-sponsored statistical study of a large sample of company records, Miller and Smith (2003) report that

> [i]nsurance scores do overlap to some degree with other risk characteristics, but after fully accounting for all interrelationships, [credit-based] insurance scores significantly increase the accuracy of the risk assessment process.[20]

The property damage liability (PDL) claim frequency of the lowest credit score decile is nearly double the frequency of the highest decile, or after adjustment for other predictor variables (like driver sex), nearly 50% more.[21]

---

19. There is constant pressure on insurers to use known predictors either as competitive tools or out of fear of adverse selection because competitors may be using the predictors to lure away customers with lower predicted claim frequencies. Schwartz (2000:644) surveyed several national insurers who said they did not use first party bodily injury claims arising from non-negligent accident involvements to raise subsequent premiums. However, evidence of pressure to do this are the laws cited by Schwartz prohibiting the practice in Hawaii and Michigan.

20. Although driver sex was provided by insurers for all cars in the study and found to be among the most significant predictors of claim frequency, driver sex does not affect the price of insurance on a sizeable majority of cars.

21. Miller and Smith (2003) Exhibits III and VI

Although Miller and Smith (2003) state that "it would be inconsistent with sound actuarial principles to require credit-based insurance scores to demonstrate a causal relationship," nevertheless they suggest one:

> [W]e could reasonably speculate that there are psychological factors that likely affect how we manage our personal lives. . . . Insurance scores seem to provide an objective means of measuring personal responsibility and its effect on insurance losses . . . ."

The connection of accidents with "personal responsibility" in financial matters is further developed by Brockett et al. (2005), as their introduction states:

> In this paper we will present evidence conceiving the relationship between credit history and predictability of risk through an analysis of the literature on biological, psychological, and behavioral characteristics of sensation seeking and how those characteristics affect financial decision making and risky driving habits.

But one immediate problem with the lack of personal responsibility and risky-driving-habits theory for why higher liability claim frequencies correlate with lower credit scores is the parallel correlation of higher UMV claim frequencies with lower credit scores. Miller and Smith (2003) do not include UMV claims among the six coverages[22] studied, while Brockett et al. (2005) discuss only AF accident involvements. However, auto insurers say that both liability and UMV claim frequencies increase together as credit scores decrease.[23] Although Brockett et al. (2005) concentrate on presumably negligent driver behavior, payment of a UMV claim requires the driver of the insured car to have been NAF, i.e., non-negligent.

II.6. Zip Code

In both rural and urban areas, automobile insurers experience the most liability, collision, and uninsured motor vehicle (UMV) claims per 100 insured car years—and therefore charge the highest prices—for covering the cars of owners living in low-income zip codes. In their study of Missouri zip codes, Harrington and Niehaus (1998) report that the residents of higher black ethnicity and concurrently lower-income zip codes produce 36% more liability claims and 48% more collision claims per 100 insured cars than the cars of residents of other zip codes. But the report suggests no explanation for these correlations.

In agreement with these findings, SRI International (1979) describes the findings of a 1978 Massachusetts Institute of Technology doctoral thesis: "In Massachusetts, the correlation between territorial rate relativities and median income is –0.978; between such relativities and percent black, 0.532; both sets of figures are stunningly high." In a study of territorial, driver sex, and other cross-

---

22. The six coverages studied are property damage liability, bodily injury liability, collision, comprehensive, personal injury protection, and medical payments.

23. For example, the results of a multivariate study of claim-frequency correlations with credit scores were described by Brady Smith, Products Development Analyst at Mutual of Enumclaw, in a panel discussion at the Society of Insurance Research annual conference, November 2003. As with other instances of parallel liability and UMV variations with claim frequency predictors, this information was delivered in a "can you believe this?" manner as if to signal an anomaly to the usual negligent driver explanation.

class subsidies that Massachusetts regulation requires, Blackmon and Zeckhauser (1991:68) point out that low income drivers produce higher costs *per car* than higher income drivers because the "subsidy of Boston and other [low-income] cities tends to flow from high-income towns to low-income towns."

Variations in insurance cost across zip codes are not considered directly by the Brockett et al. 2005 review of risky behavior studies, but it discusses studies that link risk-taking to socio-economic status (SES).

> Testosterone is positively correlated with novelty seeking, sensation-seeking and aggression. . . . Interestingly, socio-economic status provides a moderating variable to this relationship. In other words, weaker testosterone-behavior relationships were found among high SES subjects. [p. 14]

Since zip codes serve as proxies for SES and income level, the SES level of zip codes correlates negatively—according to this study—with risk taking and negligent driving behavior.

But two difficulties arise for this negligent-driving explanation. First, more liability claims—as presumed indicators of more driver negligence in low-SES zip codes—are accompanied by more UMV claims.[24] Although UMV claims were not included in any of the studies, in legislative and regulatory forums insurers assert that higher UMV claim frequencies accompany the higher liability and collision claim frequencies of cars from low-income zip codes. The difficulty with the theory of greater-negligence by low income drivers is that payment of a UMV claim requires non-negligence by the driver of the insured car.

The second difficulty is that the idea of greater negligence of drivers from low income areas conflicts with the general economic theory that people with fewer resources should be more risk averse and therefore, should be, if anything, not more but less negligent. Cars in low-income areas represent a larger portion of their owners' wealth than the cars of owners living elsewhere do. Loss of car use and repair costs are major concerns.[25]

II.7. Military Rank

The auto insurer United Services Auto Association (USAA) limits its business to the cars of active and former military service members and of their former spouses and adult children. To do this the insurer uses two companies in each state, one for officers (commissioned and non-commissioned) and the other for enlisted military and former military dependents. The company for the officers is owned by the insureds—a reciprocal company—and this company in turn owns the other company, which in Texas is one of the state's specially-chartered

24. Although this correlation between low income zip codes and higher UMV claims is not noted in academic research, it is well known in the auto insurance industry.

25. The serious consequences for some of losing use of a car was described by the *Philadelphia Daily News* in an editorial, For Many a Car is not a Luxury, November 15, 1991. "When he told me my Datsun needed a new gasket or something, I started to cry. He looked at me funny. He asked. . . 'Why would you cry over a car?' This is why: . . . not having the use of a car meant carrying her 2-year-old most of the 10 blocks to his family daycare home, then taking two buses to work, arriving exhausted. And after eight hours at work, repeating the process in reverse. Not having a car meant putting off grocery shopping and laundry. If the kids got sick. she would have to take them to the doctor on the bus."

"county mutual" companies. The reason for this dual arrangement was questioned in a committee hearing of the state Senate in 2003.[26]

> Chairman Senator Troy Fraser: Well, help me with this one. I'm in the handout here and I've compared both things you've handed out. There's a statement in here that says "county mutuals provide a unique solution for high-risk drivers." Now are we automatically assuming that it's the private first class who is a high-risk driver? . . . .
>
> USAA actuary Alice Gannon: No. Traditionally, that's how the industry tended to use it. But, no sir, actually it's not. It's a somewhat higher percent that are high-risk in enlisted ranks than in officer ranks, but there are some in both.

To judge from the Texas Insurance Department's buyer's guide for consumers, the distinctions in price between United Services Auto Association and USAA County Mutual on the basis of military rank are small, 4% to 14%. But the distinction between companies by military rank in the USAA group of companies also allows for differences in policyholder dividends which can increase the price differences.[27]

Informal explanations by academics for the correlation of higher claim frequencies with lower military rank allude to SES and educational levels.[28] As with car owners in low-income zip codes, however, the lower pay of lower rank car owners should lead if anything to less negligent driving.

II.8. No Prior Insurance

The cars of new customers that were not previously insured (i.e., cars not kept continuously insured) subsequently produce more claims per 100 car years than the cars of new customers that had had prior insurance.[29] Although the consequent higher prices insurers charge to insure cars without prior insurance

---

26. Hearing February 11, 2003 on SB 14 before the Texas Senate Committee on Business and Commerce, AM session 59 minutes after the call to order. http://www.senate.state.tx.us/avarchive/ram.php?ram=00001786&PHPSESSID=02a1969df16fa95416c95373c793eb17

27. According to data in the 2004 annual statement, the parent reciprocal company's dividend to policyholders was twice that of the company it owns, USAA Casualty Insurance Company, 7.8% versus 3.7% of premiums paid. (Presenting these facts is not intended as criticism, but as recognition that the cars of lower rank service members—all else equal—cost the company more per car year to insure.)

28. The use of SES criteria in pricing car insurance is not confined to the military. A recent investigative report on the criteria used to assign customers to the different companies of one insurer found that a janitor with a high school degree would be charged 71% more for the same coverage than a lawyer with a master's degree living at the same address. Joe Donohue, "Geico's two rates: white-collar and blue-collar: Auto insurer charges more to consumers with less formal education and job status," *Star-Ledger* (Newark, NJ), February 27, 2006.

29. For example, a press release by National Association of Independent Insurers in April 1999 in opposition to two Texas bills (HB 2500 and SB 1792) to prohibit using no prior insurance as a price criterion states that "[n]ot only do 'no priors/non-standards' incur more claims per 100 insured cars, but their average cost per claim is higher as well. . . . It simply costs insurance companies more to protect drivers who were previously uninsured or had prior coverage with a non-standard carrier than those who are insured in the standard market." The non-standard (higher price) insurers are those that sell in low-income zip codes to those refused insurance by the standard (lower-price) national companies such as State Farm and Allstate.

raise the financial barrier for compliance with state insurance requirements, apparently this predictor has yet to receive scholarly attention. In policy debates, one implied explanation is that drivers of uninsured cars are more negligent than average and continue to be negligent after newly insuring their cars. But the theory that drivers of uninsured vehicles are more negligent is in conflict with the moral hazard theory of insurance whereby driving uninsured should make drivers less negligent than if the vehicle were insured. In accord with this same moral hazard logic, however, cars driven non-negligently while uninsured once insured could then be negligently driven. However, it should also be noted that minimum insurance requirements in most states are for third party liability coverage to protect others from the consequences of negligent driving of the insured car. Unless the car without prior insurance was also newly covered by first party Collision coverage, the risk of uninsured damage to the owned car would militate against any presumed incentive for greater driver negligence.

II.9. Installment Payments

A study of European auto insurance reported that single payment policies produce 10 collision claims per 100 car years while the installment payment policies produce 20 claims per 100 car years. [This study has not yet been relocated. The general effect has been corroborated but not the actual claim frequencies.]

In the United States, payers by installment show two contrasting general patterns: Some car owners pay in installments month after month without interruption for years. Others make no further payment after the down payment, which covers two months and provides the proof of insurance needed in many states to obtain registration and safety inspection stickers. This latter pattern is repeated each year with a new company. The cars uninsured for ten months a year probably represent most of the uninsured car population.

II.10. Years With Company (Policy Age)

Each company’s class pools comprise the cars of customers who are new policyholders along with the cars of customers who have been with the company for various numbers of years. When the pools are subdivided into policy age cohorts, the average annual cost per car year decreases with the number of years the car owners have been company policyholders. Where separate information on annual claim numbers and average claim size is available, most of the decrease in cost with policy age is due to a decrease in number of claims per 100 car years. The cause of this negative correlation of claim frequency with policy-age has received attention from a number of researchers.

D’Arcy and Doherty (1990) study the decrease with policy age of average costs (losses) per car divided by the insurance price per car (the loss ratio). They theorize that a company accumulates information about its individual insureds from year to year and shifts the cars of drivers the insurer considers to be more negligent than average out of the pool either to higher-priced class pools, or completely out of the company by not renewing coverage on these cars. They explain that:

> Since the cohort will be purged of many of the bad risks over time, the average loss for the cohort should decline. On the other hand, prices should be sticky with respect to new private information generated by the firm on its policyholders. Consequently, the ratio of losses to premiums (the 'loss ratio') should decline as the cohort ages. (Page 154.)

The explanation that over time a company gains information on policyholders not available to competitors is marked "X" in column DN-2 in Table 1. Without this information competitors cannot selectively offer these policyholders lower prices.

Cohen (2005) reports Collision claim frequencies from an Israeli auto insurer, Table 2 (below), showing that the number of claims produced per 100 car years by policyholders in their fourth year with the company were 16% less (regular deductible) to 25% less (low deducible) than produced by policyholders in their first year with the company.

TABLE 2. Data from Cohen (2005:Table 5).

Collision Claim Frequency per 100 car years by 1) year with company and by 2) deductible amount				
Year with company*	1st	2nd	3rd	4th
Low deductible**	24	23	20	18
Regular deductible:	19	18	17	16

* The claims experience of each subsequent year policyholder is also included in the experience of the previous years. That is, the claims experience of the 4th-year policyholders in previous years with the company is included with the 1st, 2nd, and 3rd year experience.
** Claims larger than the regular deductible amount.

Cohen theorizes that new customers who are experienced drivers have more information on their own risk than the company has (column DN-3, Table 1).

> Consistent with the possibility of policyholders' learning about their *risk type*, such a coverage-accidents correlation exists only for policyholders with enough years of driving experience. The informational advantage that new customers with driving experience have over the insurer appears to arise in part from customers' underreporting their past claim history: policyholders switching to new insurers are disproportionately ones with a poor claims history, and new customers tend to underreport their past claims history when joining a new insurer. (p. 197, emphasis added.)

Cohen (2005) reports on an unpublished 2004 companion study of the data from an Israeli insurer that "it finds that insurers indeed make higher profits on repeat customers, and that these profits increase with the period that the customers stay with the insurer." This accords with what D'Arcy and Doherty (1990) describe above, but their reason that with passing years the company gains more information on the risk of individual customers seems more plausible than Cohen's idea that customers themselves with time are able to gain any kind of realistic sense of their own risk to insurers in either relative or absolute terms. The idea of unbiased, realistic self assessment of driving risk by car owners is considered below.

II.11. Collision Deductible Size

Among cars with collision coverage, the ones with lower deductibles average more claims in excess of the higher deductible threshold than the cars with the higher deductible. That is, cars with a $250 deductible average more claims greater than $500 than do the cars with a $500 deductible. Cohen (2005) has studied the correlation with the experience of an Israeli auto insurer and found that the claim frequencies of the low-deductible subgroup averages 2 to 5 (12% to 26%) more claims per 100 car years exceeding the higher deductible amount than the higher deductible subgroup, as shown in Table 2, above.

Cohen (2005), Puelz and Snow (1994), and others suggest that car owners selecting more coverage (a lower collision deductible) may know that their car's drivers are more negligent, as marked in column DN-3, Table 1. Using the amount of liability coverage selected as a proxy for wealth, Puelz and Snow (1994:Table 1) find that the low deductible group, which has the highest frequency of Collision claims, also has the lowest wealth. But risk aversion theory predicts less negligence with low wealth.

The positive correlation between claim frequency and amount of coverage is also observed in the choice of whether or not to buy collision coverage on the insured car itself. Lemaire (1995:4) describes this correlation and takes it as proof that car owners have more accurate information on their own negligence ("driving behavior") than available to insurers.

> It is well known that the drivers who buy optional collision coverage have a much higher claim frequency than those who purchase only compulsory third-party liability—proof that insureds know more about their driving behavior than the insurance company.[30]

However, a major problem for such a proof is the fact that a large majority of drivers believes that they are more skilled or more careful than average (Svenson, 1981, Delhomme, 1991). This belief is inconsistent with the idea that drivers can self-assess their own driving behavior and its affect on risk transferred to the insurance company.

II.12. Selection of Tort Rights in Pennsylvania

The selection by car owners between two tort-rights options divides insurance pools in Pennsylvania into two sub-pools of cars that produce different claim frequencies or severities. Since 1990 the state has provided car owners an alternative to pay a lower price by selecting a "limited tort rights" option. This option means accepting an injury severity threshold limit to the tort right (of all family household members) to sue for non-monetary ("pain and suffering") damages. The higher-priced option is to retain "full tort rights" with no threshold. The two tort-rights subclasses were originally expected to show little or no difference in insurance cost for most coverages.

In principle the only coverage where the lower priced limited-tort option can cut the average size of claims directly for the car's own subclass pool is the relatively inexpensive first party Uninsured Motor Vehicle (UMV) bodily injury

30. Although earlier Lemaire (1985, p. 76) reported that this increase was unexpected, he made the same interpretation: "the high increase—nearly 50%—in claim frequency for the insureds who took a comprehensive policy (which proves that those drivers judge themselves correctly)."

coverage.[31] In contrast, for the major-cost bodily injury liability (BIL) coverage a selection of limited-tort rights can only reduce the average size of liability claims across all insurers. Although policyholders in the limited-tort subclass on average will collect smaller liability damages, the claims are paid by another car's insurer, not their own car's insurer. In turn, the different average sizes of liability claims produced by the two tort option subclasses for their insurer to pay do not depend on the selection, but rather on the completely independent selection of tort rights by owners of cars with which the insured car randomly collides. Therefore, which alternative customers select does not affect a company's own cost of providing bodily injury liability coverage except as generally spread across all companies.[32] Because the price difference between the subclasses cannot be based on any measurable cost difference in liability claim severity, from the outset the price difference has been administered by law and regulation.[33]

The simplicity of the administered reduction can be appreciated from its expression in the 2000 State Farm manual. The manual rule for the limited-tort price reduction appears as the last step in calculating an individual premium for all coverages—including first and third party property coverages, which are unrelated to bodily injury coverages—and reads in full:

> TORT OPTIONS: The manual premiums are for policies with the full tort option. The premiums for all the coverages shall be reduced by 15.3% for policies with the limited tort option. These options apply to all eligible private passenger automobiles and commercial light farm trucks (Class 1).

Even with such relatively small administered savings applied to all coverages, Regan (2001) reports that, as expected, in Pennsylvania counties where insurance is more expensive, a larger proportion of car owners select the cheaper limited-tort option. But, surprisingly, Regan also finds that car owners

---

31. Since UMV claims are paid by the covered car's own insurer, the limited tort threshold would reduce the average size of UMV claims paid by the insurer relative to the average size of UMV claims paid to full tort electors in the same class.

32. The theoretical "out-of-balance" problem among insurance companies with different proportions of full tort and limited tort customers can be appreciated by assuming the entire state is served by only two companies: one with all full tort customers and the other with all limited tort customers. If collisions are just between customers of the same company, there is no balance problem. But when full tort cars hit limited tort cars, claims will be smaller on average for the full tort company to pay (even though it has collected larger liability premiums), but when limited tort cars hit full tort cars, the limited tort liability insurer, which has collected the lower limited tort premium will have to pay the larger full tort claim. Thus companies with more limited tort customers collect less premium but on average pay larger liability claims, whereas companies with more full tort customers collect more premium but on average pay smaller liability claims. According to the state insurance department, in Pennsylvania statewide about half of cars are covered by limited tort and half by full tort. In Philadelphia, which has the state's highest premiums, about 70% are limited tort cars and 30% full tort.

33. Administered price differences are routine in automobile insurance. Price regulation, and also price competition, commonly require auto insurers to produce discount subclasses for which there are no measured savings to support the discount. Insurers can do this by raising the cost-based class price to accommodate the discount and keep total premium revenue the same, that is, "in balance." For example, if a 20% discount is required for which an insurer expects half a class will qualify, the insurer can arbitrarily raise the class price by 1.11 times for the non-discount subclass to give the "20% discount" subclass a new price of 0.888 of the original cost-based price. (Like free lunch, there is no such thing as a free insurance discount; if not supported by real savings, the discount has to be paid for by some or all customers.)

with less income—who should be more drawn to reductions in premiums—are disproportionately selecting the greater coverage that the more expensive full-tort option provides.

Recently other differences have become apparent. For a number of years industry professionals have been informally reporting unexpected directly-experienced cost differences between the tort option subclasses. Then in 2004 the Pennsylvania Insurance Department ordered insurers to reflect the cost-based differences in premiums.[34] The results, which replace the simple 15.3% reduction rule quoted above, are shown by the State Farm manual's new rule in Table 3. As before, full-tort prices are still the bases for the limited-tort reductions but they are now coverage-specific, differ by territory, and, for the coverages affected, are larger than the previously administered reductions.

TABLE 3. Premium Differences by Tort Option

<table>
<tr><td colspan="2">State Farm Pennsylvania Manual [effective Dec. 2005]</td><td rowspan="3">Claim payment requires driver of insured car to have been judged</td></tr>
<tr><td colspan="2">TORT OPTIONS. The manual premiums are for policies with the full tort option. The premiums for policies with the limited tort option shall be reduced by the percents listed below. The limited tort option applies to all eligible private passenger automobiles . . . .</td></tr>
<tr><td>Coverages</td><td>Percents</td></tr>
<tr><td>Bodily Injury and Property Damage Liability:</td><td></td><td rowspan="3">Negligent</td></tr>
<tr><td>Territories 5, 9, 10, 30, 36, 43, 44, 45, 50, 51, 52, 54, 60†</td><td>26%</td></tr>
<tr><td>All Other Territories</td><td>20%</td></tr>
<tr><td>Medical Payments, Loss of Income, Combined Benefits . . .</td><td></td><td rowspan="3">*</td></tr>
<tr><td>Territories 9, 10, 30, 40, 43, 44, 45, 50, 52, 54, 55†</td><td>45%</td></tr>
<tr><td>All Other Territories</td><td>40%</td></tr>
<tr><td>Uninsured Motor Vehicle Coverages (U,U3), and Underinsured Motor Vehicle Coverages (W,W3):</td><td></td><td rowspan="2">Not negligent</td></tr>
<tr><td>All Territories</td><td>45%</td></tr>
<tr><td>All Other Coverages**</td><td>0%</td><td>*</td></tr>
<tr><td colspan="3">† Bold numbers added here to designate Territories not common to the two types of coverage. (Territories 9, 10, and 30 compose Philadelphia County.)
* Claim payment is not contingent on whether or not the driver was judged to be negligent or not-negligent when the accident occurred.
** The most expensive of these by far is the first party Physical Damage coverages (collision and comprehensive) of the insured car itself.</td></tr>
</table>

What this table shows, surprisingly, is that the cars insured under the full-tort option preferred by lower income car owners also produce more cost per car-year for insurers to cover.[35] The tort-rights selection by car owners is apparently

34. http://www.ins.state.pa.us/ins/cwp/view.asp?A=11&Q=543504 [Details of the full tort vs. limited tort claim-frequency correlations have not yet been verified, but the higher loss costs insurers report for both first-party bodily injury (including UMV) and third-party liability coverages suggest as the reason higher accident frequency instead of greater claim size.]

35. Whether the "more cost" to cover is due to more accidents or more-expensive accidents or both has not yet been learned. As a general rule, more accidents and claim frequencies dominate cost differences between classes. That should mean that "other coverages" at the bottom of Table

splitting each insurance class—defined by territory, driver age, car use etc.—into two distinctly different subclasses of cars. To the fact noted above that lower income car owners apparently prefer the more expensive full-tort rights, Table 3 adds a second surprising fact that apparently the cars of low income owners produce more insurance cost per car year.

Since the driver negligence explanation would be that low income drivers are more negligent than average, Table 3 includes a column on the right headed "*Claim payment requires driver of insured car to have been judged*." While higher liability cost requires that the drivers have more at-fault, i.e., negligent accidents per car year, the higher Uninsured Motor Vehicle cost requires that the drivers of the same subclass of cars have more not-negligent accidents with uninsured cars per car year. The lesson, then, is that driver negligence and non-negligence seem to be irrelevant to explaining the full-tort versus limited-tort cost difference between the tort option subclasses of cars.

In addition the explanation that those who choose greater tort-rights coverage do so because they know that they are more negligent than average (Table 1 column DN-3) seems contradictory in this case. In choosing to retain full-tort rights, car owners are not showing concern about their own negligence but are actually choosing the greater coverage against the consequences to themselves and their families of *negligence by others*.[36]

III. Explanations Based on Odometer Miles

III.1. Exactly What Activity Does Auto Insurance Deter?

Rival to the driver negligence theory to explain accident frequency predictors is the theory that the correlations proxy for group average odometer miles. Threshold to acceptance of this explanation is acceptance of the fact that private passenger auto insurance premiums are currently charged, and reacted to by consumers, strictly as a cost of car owning. Beyond acting as a lump sum tax on income, which may impinge on the consumption of gasoline, in no sense do auto insurance premiums act as a cost of operating a car. This fact requires emphasis because scholarly papers state or imply otherwise: that auto insurance prices deter driving. For example, in synthesizing principal findings from a conference on price deregulation for property-casualty insurance, Cummins (2001:12) strongly implies that to the extent insurance rates are competitive they act like a mile-by-mile marginal cost of driving.

---

3 should also show a percent difference. However, for regulatory reasons negotiated with insurers, experienced differences in claim frequencies are not always recognized in price differentials.

36. This motive of self-protection—and the protection of family members—is urged by the Pennsylvania Trial Lawyers Association's current public information pamphlet (dated 2001) in a series of statements (selected, but emphasis original): "Insist on full tort: It gives you the unlimited right to sue for pain and suffering. Limited tort *can limit this right,*" "Limited tort restricts your right to collect for personal injuries," "Shouldn't your family members also have the right to collect? Under limited tort they don't," and "*Your limited tort* will keep your children from being able to collect, even when they're in a car driven by someone who has full tort."

> Drivers decide how much and how safely[37] they drive based on the marginal costs and benefits of driving. If high-cost drivers do not pay the full marginal costs they impose on the system, they will have an incentive to *drive more* and take less care; and if low-cost drivers pay more than their marginal costs, they will *drive less*, than under competitive rating. (Emphasis added.)

But, in fact, per-car premiums in all states—whether regulated or under competitive rating—are specified and paid in advance so that unlimited mileage can be subsequently driven. There is no marginal cost to a driver for each mile driven, despite the risk each mile transfers to the car's insurer. Even though a company may apply a mileage surcharge (or discount) according to unverifiable representations on the application or renewal form of what the Texas Auto Insurance Manual (Rule 74G) calls "estimated [future] odometer mileage," insurers do no back billing (or refunding) at the end of the policy period regardless of how many miles (or few or even none) a car's odometer may actually have recorded. As a consequence, insurers charge insureds in the same class nearly identical premiums for a lot of driving and for no driving.

Table 4 presents six cases to show how different arrangements strongly affect the amount of premium paid for insuring 20,000 vehicle miles of travel under a hypothetical $500 per car year base premium. The most simple arrangement is one car traveling the entire distance in a year, Case U. Dividing premium by vehicle miles traveled (VMT) shows that the insurer collects 2.5 cents a mile in this case. However when a household uses two cars to drive 20,000 miles in a year, or takes two years to drive the same distance in one car, then the amount paid arbitrarily jumps from 2.5 cents to 4 or 5 cents a mile, as shown by Cases V and W.

TABLE 4. Premium paid for 20,000 insured vehicle miles traveled (VMT)†

CASE	Annual miles per vehicle	Vehicles used to travel 20,000 miles a	Years taken to travel 20,000 miles b	Annual Premium per vehicle c	Premium for 20,000 VMT d (= a x b x c)	Premium per VMT (= d / 20,000 miles)
U	20,000	1	1	$500	$ 500	2.5 cents
V	10,000	2	1	400*	800	4
W	10,000	1	2	500	1,000	5
X	6,667	1	3	400**	1,200	6
Y	4,000	5	1	320***	1,600	8
Z	2,000	1	10	400**	4,000	20

† Hypothetical $500 base annual premium for a given "car-use" class such as Pleasure Only. The discounts applied are of typical size.
* 20% multi-car discount.
** 20% discount for less than 7,500 estimated future mileage.
*** Both discounts.

37. As I discuss in working papers elsewhere, how safely driver groups drive, and, in particular, the effects of a safety device on reducing per-mile risk rates, can only be evaluated with statistical credibility for well-defined classes of cars based on the aggregate accidents or claims each class experiences during upward of 100 million odometer miles of driving exposure. *See*, for example, Butler (2006) working paper #752.

The last three cases (X, Y, and Z) show that the company would be collecting from 6 cents up to 20 cents a mile for the same insurance. The company is obviously collecting much more in total premium—and much more per mile—for the same risk transferred to it and so is making much more profit from owners of cars driven few miles in a year's time. Any cross subsidies go to those using a single car to travel many miles in a year's time—as in Case U. In fact, premiums are a cost of car owning and therefore can affect only the number of cars owned.[38]

Earlier criticisms of auto insurance premiums as lacking an incentive bearing on how much to drive were made by Williamson, Olson, and Ralston, (1967:248), who wrote that "the auto insurance premium . . . acts as a lump-sum rather than a marginal tax." and by Vickrey (1968:470), who concluded that rates "provide incentives that are largely inappropriate at the margins where decisions are actually made as to . . . whether to make a given trip by car."

III.2. The Two Kinds of Variable Essential to Assessing Risk

The odometer-miles explanation engages with the two kinds of variable that are essential to the measurement of individual driving risk: 1) one kind comprises the several categorical *classification* variables that determine how cars are classified, and 2) the other kind is the single continuous *exposure* variable that serves to measure the exposure of individual cars to risk. An analogy highlights the difference.

Retail gasoline sales can involve as many as twelve price class categories. The three categorical variables that distinguish these classes are three octane levels, self or full service, and cash or credit payment: 3 x 2 x 2 = 12 prices. However, common to all of the price classes is the single continuous gasoline gallon variable. Similarly, automobile insurers define price classes by categorical variables such as residence territory, car and driver characteristics, and car use, but common to all of the classification variables is a single continuous exposure-unit variable.

Three familiar exposure-unit variables are currently used to determine premiums for motor vehicle insurance:[39] the car-year variable is used for private passenger cars and many commercial vehicles, the odometer-mile variable is used for some fleets of commercial vehicles, and the gasoline-gallon variable, although much discussed, has been used only in minor ways. Despite their broad or proposed use, however, two of these three exposure-unit variables entail a major but different deficiency.

---

38. Blackmon and Zeckhauser, 1991, report for Massachusetts: "The demand for insured vehicles per household was estimated as a log-linear (constant elasticity) function of income, price [of insurance], and household density." And "Our estimated coefficients were income 0.477, price –0.569, and density –0.044." This large negative effect of per-car insurance prices on car registrations has been confirmed across states by Pritchard and DeBoer (1995) and for California by Jaffee and Russell (1998:107).

39. Small gasoline surcharges at one time were minor sources of insurance funding in New Zealand and in several Canadian provinces. Another exposure measure that is used for public cars such as limousines and buses is gross receipts; a class rate is expressed as a percent of receipts, e.g., 8 percent, or $8 per $100, of receipts.

The problem with the traditional car-year variable is that while allowing for classifying cars, it allows no within-class measure of individual exposure.[40] On the other hand, the gasoline-gallon variable, absent a special arrangement to classify cars at the pump, has just the opposite problem. Although a per-gallon surcharge would provide a continuous measure of individual exposure, it also would preclude classification of cars by such important risk variables as driver age, car type and value, and amount of coverage. Thus, a surcharge on gasoline would exchange today's classification-only, no-variable-related-to-individual-exposure system for an individual-exposure-variable-only, no-classification-variables system. In contrast to these two deficient systems, a system using the odometer mile exposure unit would perform both functions: different class per-mile prices would be multiplied by the exposure variable (odometer miles) for each car to determine individual premiums.

Although the following explanations apply to 12 predictor categorical variables based on the current *car-year exposure unit*, the average odometer-miles theory relies on the fact that the cost of continuous individual production of risk can be efficiently measured by the product of an *odometer-mile* variable multiplied by a cents-per-mile risk rate variable. For example, 10,000 odometer miles times 5¢ per mile equals $500.

III.3. Group A: Driver Sex and Car Age

With reference back to the 12 predictor variables listed in Table 1, the first two, driver sex and car age, are taken together as Group A. Periodic Federal household transportation surveys give information not only on annual mile averages by car age and by driver sex and age, but also the annual miles distributions within these categories. Men at every age average more miles of driving and concurrently more state-reported accident involvements than women the same age. However, by adjusting the driver age and marital status definitions of price classes, insurers confine direct pricing by driver sex to a minority of cars.[41] Where insurers do use driver sex, the price classes serve as proxy odometers for the average annual miles of cars categorized by driver age, sex, and marital status. Figure 2 shows the bimodal and positively skewed distribution of cars by annual odometer miles. But pricing of any or all cars by driver sex is wildly inaccurate for individual cars.[42]

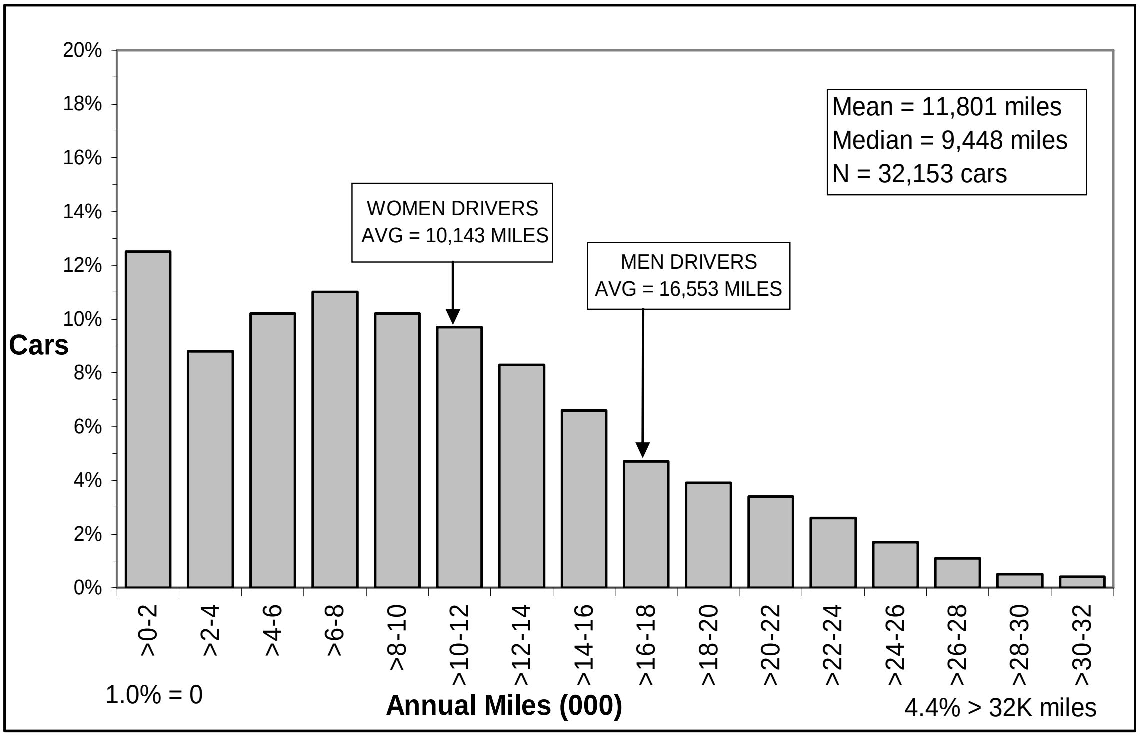
---

40. The car-year exposure unit—with the car-day as current least count—is obviously the appropriate variable for measuring the risk transfer of full time coverages, such as theft, flood, and hail.

41. Discretionary use of pricing rules to favor some customers is noted for French insurers by Chiappori and Salanié (2000:71) where a company may allow—evidently contrary to its guidelines—a young driver to share a parent's Bonus discount ("earned" by years of claim-free liability coverage) but that "a typical insurance company will be reluctant to accept such a deal unless the father is a good customer."

42. The distribution of cars by annual miles is positively skewed because from three-fifths to two-thirds of cars are driven less than average, overall and for different car age groups. 1995 NPTS age group and overall average miles from Hu & Reuscher, 2004, Table 22.

FIGURE 2. Distribution of Cars by Odometer Miles in 1995



In separate distributions of men and women drivers by annual miles and by annual accident involvement probabilities, the miles and probabilities of a large minority (about 30%) of men drivers are less than the averages for women drivers, and concurrently a somewhat smaller minority (about 12%) of women drive more and have a greater probability of accidents than men's average miles and accident probability.[43]

Federal travel surveys also confirm common knowledge that older cars are driven less than newer cars, Figure 3. In fact Pinquet (1999:50) observes that

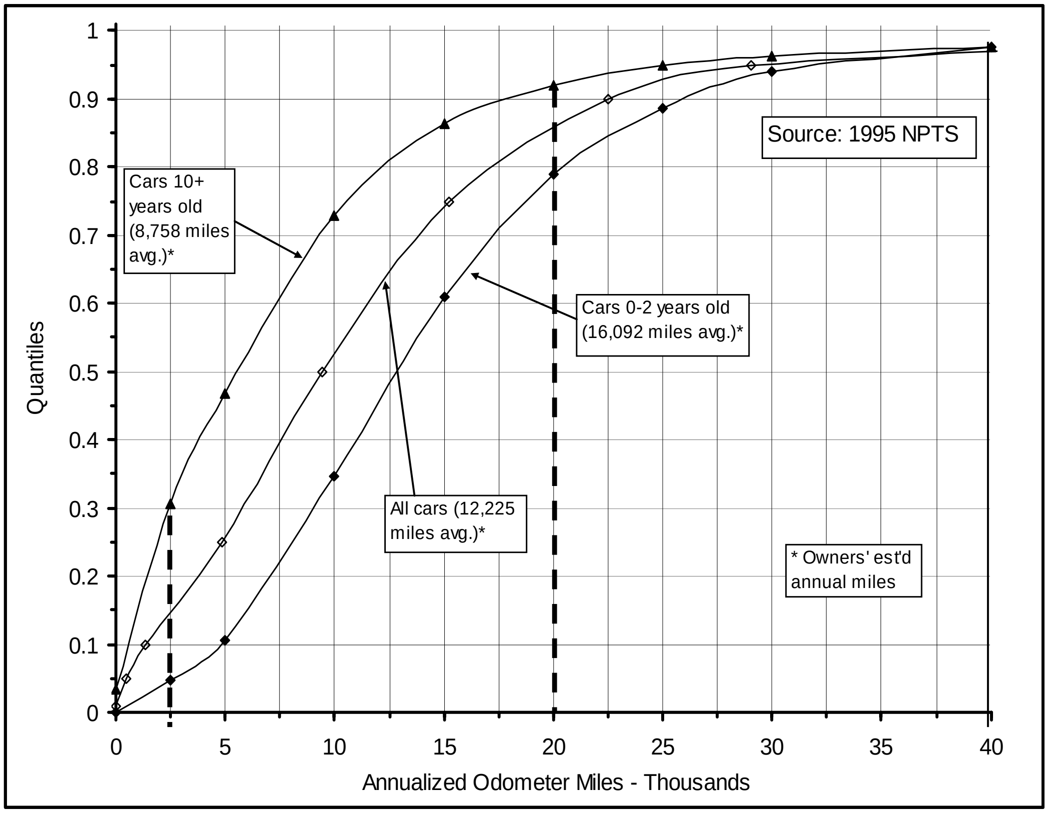
> hidden variables are correlated with observable ones: for instance, the age of a vehicle is a good proxy for annual mileage.[44] The price of second-hand cars depends more on their age than on their mileage, so the less you drive, the more you are financially incited to buy a car second-hand, and to keep it as long as possible. This explains the significant influence of the age of the vehicle on the frequency risk.

43. Butler et al., 1988, pages 395-401.

44. The distinction here between *hidden* and *observable* variables implies that a car's age but not its odometer is observable by insurers. Despite being ignored by insurers, however, by law a car's odometer must permanently and observably record each mile the car is driven. Rather than incorrectly being called a hidden variable, odometer miles are in the category of "unused observables" that are not used for prices by insurers despite availability and correlation to risk. This insurance practice is analyzed by Finkelstein and Poterba (2006) in a study of the British annuity market. They note that in many insurance markets, including automobile insurance, "asymmetrically used information occurs because insurance companies choose not to use risk-related buyer information that they collect, or could collect, to set prices." They investigate whether or not buyers themselves instead might be making use ("asymmetrically") of the risk-related information to their own advantage.

Nonetheless, categorizing cars by age would be using the category averages as proxy odometers, when the use of real odometers is called for. Despite the large spread in annual mile averages represented by car-age categories, federal surveys show that several million late model cars are only driven a few thousand miles a year while many million older cars are still driven above average miles.

FIGURE 3. ***Annual Miles Distributions of Cars by Age Group***



The overlap between new and old cars in annual miles is illustrated in Figure 3 at two annual mile values marked by dashed vertical lines. Among the household cars extrapolated to be driven less than 2,500 annual miles are nearly 5% of the new cars zero to two years old, and 31% of the old cars ten or more years old. Similarly among the cars driven more than 20,000 annual miles are 8% of the old cars and 21% of the new cars.

III.4. Group B: AF and NAF Accidents

Traffic accident involvements can be modeled as a process of random sampling of cars.[45] But unlike balls sampled from an urn, cars assigned to an insurance pool are not equally likely to be picked at random by an accident. They differ from each other by the number of miles each is exposed on the road to being sampled. While accidents randomly pick the pool's low annual miles cars along with middle- and high-miles cars, an accident sample of the pool obviously will not represent the mix of cars assigned to the pool but rather the proportions of

45. Such models are described and compared with insurance company surcharge schedules and state accident-involvement records by Butler and Butler (1989) and by Butler (1993b).

miles these cars travel on the road. Therefore, the accident sample of cars in an insurance pool will be biased to the cars driven more miles.

The biasing process can be modeled by an imaginary insurance class pool composed of a mix of 2/3 5K annual-mile cars and 1/3 20K annual-mile cars, which approximates the highly skewed distribution of cars shown in Figure 2. This mix produces a pool overall average of 10K annual miles per car. After three years at a road sampling rate (with replacement) of 5 accident-involvements per 1 million mile traveled, the pool may be divided into a large accident-free main pool and a small accident-involved sub-pool. In the main pool the proportion of 20K mile cars is slightly reduced lowering the average annual miles from 10K to about 9.93K annual miles per car. But the accident-involved group shows a large increase in the proportion of 20K annual miles cars from 1/3 of the undivided pool to nearly 2/3 of the small accident-involved sub-group. Thereby its average miles becomes 14.6 K miles per car year, which is nearly 50% more than the pool 10K miles overall average.

It is inescapable that accident samples of insurance pools will be biased to sharply greater annual miles per car averages. Higher average miles per car will mean proportionately more claims per 100 car years. Furthermore, accidents as a random sampling process are indifferent to which of the accident-involved cars happened to have had drivers negligent at the time and which cars did not have drivers negligent at the time.

The correlation lends support to the idea that sub-groups of cars whose drivers have been involved in an accident in the past continue in the future to be driven more miles than average. But this parallels the driver negligence idea that sub-groups of cars whose drivers are found negligent in past accidents will as a sub-group of their class continue to be negligent in the future.

Where the group average odometer miles theory surpasses driver negligence theory in explaining accident-record predictors is that higher group average odometer miles per car predicts not only more liability claims per 100 insured car years for the group, but more accidents and claims of all kinds, at-fault and not-at-fault. This conclusion accords with the second suggestion by Lemaire (1985) that "it may be that those who drive a great deal and spend a greater than average amount of time on the road are liable to have more accidents, whether they are responsible for the accidents or not."

III.5. Group C: Credit Score, Zip Code, and Military Rank

In Table 5 below, Group C comprises three variables whose values tend to separate car owners according to financial status. The variables are an indication of how strongly car owners might need to economize on auto insurance as well as on all other expenditures. Owners residing in low-income zip codes, owners in all zip codes with straitened financial circumstances indicated by low credit scores, and owners with low military rank all evidence a stronger need to economize than do owners living in higher income zip codes, with higher credit scores, or a higher military rank. If insurers decide in deference to favored constituencies to disregard some proxy-odometer variables, such as car age entirely and driver sex for a large majority of cars, then it is logical to expect insurers to employ other proxy-odometer variables when the constituencies affected are not so favored. This is true for residents of low income zip codes whose insured cars produce

TABLE 5 – *Self Selection and the Average Odometer Miles Explanation*

PREDICTORS OF CLAIMS PER 100 CAR YEARS			SELECTION BY CAR OWNERS AS AN ECONOMIZING RESPONSE TO THE "PER-CAR" PRICE STRUCTURE				RISK AVERSION by car owners
GROUP	CORRELATION.	PREDICTOR VARIABLE of Claim Frequency per 100 Car Years - (Where binary, the higher frequency value is shown)	Self Selection **increases** pool average odometer miles "**A**dverse **S**election" (AS) against pool		Self Selection **decreases** pool average odometer miles "**F**avorable **S**election" (FS) for pool		
			Owners select <avg. miles cars **out of** class pool of current company AS-1	Owners select >avg. miles cars **into** class pool of new company AS-2	Owners select >avg. miles cars **out of** class pool of current company FS-1	Owners select <avg. miles cars **into** class pool of new company* FS-2	RA
C	–	Credit score	X**				
"	–	Zip code average income	X				
"	–	Military rank	X				
D	+	Prior insurer? - No		X			
"	+	Pay by Installment? - Yes		X			
E	–	Years with company		X	X		
F	–	Collision deductible	X				X
"	+	Pa. Tort Rights - Full	X				X

* To date this research has not identified any circumstance that would motivate this kind of favorable self selection by car owners. However, insurers themselves do attempt to select less-than-average-miles cars into company pools, which, when successful, the industry calls "skimming the cream."

** As in Table 1, "X" indicates that the theory is applied to the correlation. Multiple theories ("X X") apply in combination to explain the correlation.

more claims per 100 car years than produced by the cars of owners living in nearby zip codes.[46] Similarly, the stigma of poor credit is making it politically feasible even in higher income areas for insurers to use the correlation of higher claims per 100 car years with low credit scores as a basis for higher prices.

As is the case with men's cars and newer cars, category values producing more claims per 100 car years are evidencing more miles driven per car. Even though low-income drivers average less driving, the insured cars they share must be driven more than average to account for more than average claims per 100 car years. However, unlike their treatment of newer cars and adult men's cars, insurers do not disregard the differences in claim frequencies and therefore do not merge the claims from low-income zip codes with the claims from neighboring higher income zip codes.

The basis for the sharing-insured-cars explanation was described in 1968 by the co-winner of the 1996 Nobel Prize in Economics (for other studies), William Vickrey. In enumerating obvious economic harms caused by charging for insurance as a cost of owning a car, he included these two: "The premium structure thus has the general effect of promoting excessive use of a given stock

46. *E.g.*, urban area zip codes in Missouri that contain higher black (and concurrently lower-income) populations average 8.25 liability claims per 100 insured car years which is 36% more than the 6.06 claims averaged by car owners living in the other urban area zip codes. Harrington and Niehaus (1998:454).

of cars and undue stinting on the ownership of cars." Vickrey (1968:471). Although Vickrey noted the harm to the automobile manufacturing industry (471-72), neither he nor any other economist since has identified the apparently not-so-obvious harmful feedback effects the insurance price structure must have on some of the prices themselves.

The first theoretical description of how undue stinting on ownership of cars and excessive use of a given stock of cars must cause high insurance prices in low income zip codes was published in a report to the Texas Legislature by Butler (2000:18). Drivers who want to economize on automobile insurance buy less of it. Since the purchase unit is a car year (divisible into car days), these drivers first take their less-driven, marginal cars out of insurance pools and then they share cars kept insured. But each action constitutes adverse self-selection against the pools: first by taking more premium than miles out of the pools, and then by adding miles without premium to the pools by sharing insured cars. When insurers react to more claims per 100 car years by increasing the price of coverage per car in what they call hard-to-serve zip codes,[47] the price increase can set off an upward spiral of fewer insured cars, more odometer miles per insured car, more claims per 100 car years, and further increases in the per-car price of insurance.[48]

III.6. Group D: No-Prior-Insurance and Installment-Payments

Like Group C, Group D variables (Table 5, above) sort out car owners and drivers who show their need to economize by allowing insurance to lapse on a car and by paying premiums in monthly installments. But Groups C and D differ in the adverse selection action taken, as between columns AS-1 and AS-2. The Group C economizing, car-sharing drivers allow insurance to lapse on cars being used less than average. But when Group D economizing, car-sharing drivers decide to insure a newly-acquired car or a car without continuous prior coverage, they will seek to insure cars for which more driving is planned. Therefore, cars without prior insurance are likely to be driven more than the average miles of the insurance pools they are entering. As subgroups averaging more miles per car, they will also produce more claims per 100 car years compared with the main pools.

Similarly, owners who keep cars insured through monthly payments are more likely to have cars that are driven more miles than the averages for cars that are kept insured with semi-annual or even annual payments. For example, if a pool average odometer miles is 10,000 per year, then cars insured through installment plans are more likely to be 20,000-annual-mile cars than cars driven 5,000 miles in the coming year. Occasionally legislators accuse insurance

47. The price increase may not be directly targeted at a zip code. Instead the increase results from standard companies using underwriting criteria that refuse insurance to most car owners in the zip code. Therefore, these owners are forced to buy higher-priced insurance from non-standard companies. In some cases, the companies with higher prices are members of the same corporate group as the lower-priced companies, as previously noted in section II.7 on the Military Rank predictor of claim frequencies.

48. From this analysis, it is a wrong assumption that adverse self-selection against an insurance pool can be contained by further sub-classification because the selection occurs at the low-miles margin of any new sub-class created.

companies of not offering installment payment plans as a way of refusing to insure the cars of lower income drivers. If true, as is likely, this would be a rational business response to the correlation of a need to pay in installments with higher claim numbers per 100 car years.

III.7. Group E: Years with company

The frequency of claims per 100 car years decreases with the number of years policyholders have been with an insurance company. The first year cohort produces the greatest number of claims per 100 cars, and with each year the claim frequency for the cohort decreases. The size of the cohort also steadily decreases from year to year because typically from 5% to 25% of policyholders do not renew with the company.[49]

The theory of favorable self-selection in response to the per-car price structure holds that as a policy cohort ages with a company, car owners that leave the pool are predominantly those with the greatest need to economize. Their cars average more miles as a subgroup of their age cohort. By leaving for another company, they take more miles (and cost) than premium from the cohort. Thereby the average miles per car decreases for the age cohort remaining with the current company and with it the number of claims per 100 cars also decreases, Table 5 (above), Column FS-1.

According to the theory, the cars preferentially leaving one company's pools from various policyholder-age cohorts are biased to higher average miles. These cars simultaneously comprise a higher proportion of the new cohorts of first-year policyholders in the pools of all of the other companies. Car owners with a greater need to economize are also those who would make the effort to shop for lower prices and to complete multiple applications, particularly in response to advertisements promising savings of 15% or more. But bringing more odometer miles per car than premium to the new company's pool constitutes adverse self-selection *against* the new company pool, Table 5, Column AS-2.

Kofman and Nini (2006) and Cohen (2005) report that insureds that have just had a claim will preferentially switch companies over insureds without a recent claim. This finding seems reasonable because where companies surcharge prices for filing a claim, it increases the financial incentive that causes more car owners who need to economize to switch to a company offering a lower price (which may or may not include a claim-record surcharge such as the one levied by the former insurer).

III.8. Group F: Deductible Size and Choice of Full Tort

To explain why car owners who forgo a premium reduction in order to retain more coverage also tend to average more claims per 100 car years, the current explanation assumes that these car owners know that the car's drivers are more negligent than average. As a more plausible alternative—particularly in

49. Companies that serve lower-income markets as expected have the higher non-renewal rates.

view of how unrealistically drivers assess their own risk—I will appeal to the Law of Demand and risk aversion theory.[50]

When people want to gain large savings, they will insure fewer cars for their driving needs. But this action adversely selects (Table 5, Group F, AS-1) against the insurance pool by raising the average annual miles per car and experienced claims per 100 car years for the lower-deductible subpool. So why do these same people—who share cars to save—not also seek the smaller savings from a larger collision deductible or less tort coverage?

According to risk aversion theory, people with less income are more averse to the same risk (e.g., the $250 difference between a $250 and $500 deductible) than people with a higher income. Only the relatively wealthy will take small risks (to them) in order to gain small savings. Their economizing opposites, who by sharing and insuring fewer cars are accepting this inconvenience for large savings, are also averse to the risk (Table 5, column RA) from a higher deductible and therefore decline relatively small insurance savings on the cars they do insure.[51]

Cohen and Einav (2005) find that risk aversion—indicated by more coverage—and insurance risk per car year (currently accepted as a measure of greater driver negligence) are positively correlated, which seems to them to set up a conflict with risk aversion theory. However, in agreement with this paper, they suggest that

> the extent to which individuals drive more carefully may not be the primary determinant of the risk posed by an individual policyholder. The intensity of vehicle use, for example, might be a more important determinant of risk. If individuals *who are more risk averse also drive more miles per year*, a positive correlation between risk and risk aversion could emerge. (Ms. p. 25, emphasis added.)

According to my analysis, the suggestion here that risk aversion is linked to more miles *per car* is actually inevitable because both relate to less wealth. More annual miles per car is a Demand Law reaction by low-income drivers to the fact that automobile insurance is sold in time period units.

---

50. While still claiming that individual car owners can assess their own annual risk better than auto insurance companies can, Chiappori and Salanié (2000:74) do realistically note that car owners can assess their own *risk aversion* better than insurers can, as stated in the following:

> While theoretical models concentrate on one particular source of adverse selection—the individual's better knowledge of her risk—the empirical relevance of this exclusive emphasis is not always guaranteed. Risk is not the only possible source of informational asymmetry and probably not the most important one. There are good reasons to believe that individuals know better their own preferences and particularly their level of risk aversion—an aspect that is often disregarded in theoretical models.

51. Polinsky (2003:59) explains risk aversion with the example that "[partners in law firm vs. associates] can average out the results of many risky cases and, because they have more wealth, they can better absorb the risks that remain." A footnote further explains that "[t]his statement obviously assumes that the higher a person's wealth, the less averse he is to a given size risk. This is a standard assumption in the economic analysis of risk." In regard to automobile collision coverage, car owners with higher wealth will retain the risk of the $250 to $500 deductible loss for a discount. Risk averse lower income car owners will pay additional premium to transfer the $250 risk to the insurer.

For the same reason, the risk aversion signaled by the choice of full-tort coverage instead of the cheaper limited-tort coverage in Pennsylvania should correlate positively with more odometer miles per car year and higher claim frequency per 100 car years, Table 5, columns AS-1 and RA.

IV. Conclusions

Both theories to explain variations in claim frequencies per 100 car years posit the existence of an unmeasured cause proxied by the predictive variables considered. Either the variables serve as proxies for driver negligence, or they serve as proxies for average odometer miles.

Three kinds of predictors are most telling *against* the driver negligence theory and *for* the odometer miles theory. First, insurers find that in using accident involvements, fault is predictively irrelevant. This fact is incompatible with the driver negligence explanation, but it is a necessary consequence of the average odometer miles explanation because more miles per car means more accident involvement per 100 car-years regardless of fault.

Second, if insurers used the car age predictor, driver negligence theory could not explain why negligence increases when an old car is traded for a newer one. But this predictor *is* explained by the known decrease in average odometer miles with car age.

Third, to explain the predictor variables that proxy for straitened financial condition, the driver negligence theory—often by implication in default of an alternative explanation—further stigmatizes low-status groups as high-risk (or "bad") drivers. But the odometer miles theory explains that the correlations are the irresistible result of Demand Law reactions to insurance charged as a cost of car owning. The car-year price structure actually forces—against the will of owners—adverse selection of marginal, low-miles cars out of insurance pools and thereby creates hard-to-serve, self-destructive markets.[52]

Ironically, strong enforcement of mandatory insurance is tantamount to an attempt to force below-average-miles uninsured cars back into insurance pools. The odometer miles theory, however, suggests that increasing the risk of arrest for driving uninsured cars also forces more miles onto the cars that are already being kept insured. Then more miles per car in turn increases insurance prices which

---

52. Understanding the current adverse self-selection spiral, which affects about 20% of the market, gives insight into why established insurers might be extremely reluctant to offer a cents-per-odometer mile alternative to their current dollars-per-car-year prices. The stability of 80% of the current market absolutely depends on the financial ability of owners of cars annually driven less-than-average miles to pay premiums tied to the average miles per car year of their class risk pools. Offered a choice, many of these owners would switch their cars from car-year to matching odometer-mile class pools. As now when economizing drivers take less-than-average miles cars out of today's car-year pools, the switch to odometer-mile pools would take more premium than miles from the traditional pools. The annual miles per car—and claim frequency per 100 car years of the pools—would rise. The inevitable rise in car-year prices would cause more owners of cars driven less than their pool's rising average miles to switch them to odometer-mile pools. But, instead of a threat, such a spiraling effect would represent an opportunity for a startup company selling automobile insurance only by the odometer mile.

force more marginal cars out of the insurance pools. This dilemma seems to be an unavoidable consequence of charging for insurance as a cost of car owning.[53]

Finally, it is worth noting that further evaluation of the driver negligence theory could be pursued if the confounding effects of differences in odometer miles were removed. It may be true on an odometer mile basis that the cars driven by accident prone[54] drivers—identifiable perhaps by criteria such as credit history—who not only negligently cause more accidents, but are also more involved than average in contributorily negligent accidents caused by the negligent acts of other drivers. In establishing the degree to which this is the case, however, the lesson of the odometer-miles explanations for claim-frequency predictors is that the statistical basis for comparisons of insurance data must be the odometer mile. But this is not because the current car-year basis is an approximation that needs refinement. In fact, consumer reaction to insurance charged as a cost of car owning actually creates differences in insurance class odometer-mile averages and thus in class claim frequencies per 100 car years where none would exist absent the effect of this price structure. As a consequence, to be meaningful, claim frequencies used as tests of the driver negligence theory must be analyzed directly on an odometer-mile rather than the traditional car-year basis.

53. The automobile insurance industry response to this dilemma is to oppose adoption and enforcement of mandatory liability insurance, and to urge its rescission where adopted, as the industry has adamantly but quietly (to avoid public relations problems from openly opposing a popular mandate) done in state legislatures since at least the late 1920s.

54. The "accident prone" worker theory that a small minority of workers cause most industrial accidents rather than the risk-producing activity of all of the workers has been discredited. Baker et al. (1991:131).

REFERENCES

Abbring, Jaap, Pierre-Andre Chiappori, and Jean Pinquet, (2003) “Moral Hazard and Dynamic Insurance Data,” *Journal of the European Economic Association* 1, 767–820.

Baker, Susan P., Brian O'Neill, Marvin J. Ginsburg, and Guohua Li. 1991. *The Injury Fact Book*. 2nd ed: Oxford University Press.

Bickerstaff, David R., (1972), Automobile Collision Deductibles and Repair Cost Groups, *Proceedings of the Casualty Actuarial Society* vol. 59, 68-117

Blackmon, Glenn, and Richard Zeckhauser, (1991), Mispriced Equity: Regulated Rates for Auto Insurance in Massachusetts, *American Economic Review*, 81:65-69

Brockett, Patrick L., Linda L. Golden, and Sandra H. Dunn, (2005), Biological and Psycho-behavioral Correlates of Risk Taking, Credit Scores, and Automobile Insurance Losses: Toward an Explication of Why Credit Scoring Works, *World Risk & Insurance Economics Conference*, August 9, 2005, Salt Lake City, Utah.

Butler, Patrick (1993a) Operation of an Audited-Mile/Year Automobile Insurance System Under Pennsylvania Law, Spring 1993 *Casualty Actuarial Society Forum* 307, www.casact.org/pubs/forum/93sforum/93sf307.pdf

Butler, Patrick (1993b), Cost-Based Pricing of Individual Automobile Risk Transfer: Car-Mile Exposure Unit Analysis, *Journal of Actuarial Practice*, 1:51-84.

Butler, Patrick, (2000), Why The Standard Automobile Insurance Market Breaks Down In Low-Income Zip Codes: A Per-Mile Analysis, *Texas National Organization for Women: Report to The Texas Legislature*, 37 pages. www.centspermilenow.org/633b-4522.pdf

Butler, Patrick, (2006), Driving With the Brakes On: Guido Calabresi’s Failed 1970 Auto Insurance Case Against Safety-Device Mandates, WP #752, http://law.bepress.com/cgi/viewcontent.cgi?article=1827&context=alea

Butler, Patrick, and Twiss Butler, (1989), Driver Record: a Political Red Herring That Reveals the Basic Flaw in Automobile Insurance Pricing, *Journal of Insurance Regulation*, 8:200-234. www.centspermilenow.org/Reprints/394.pdf

Butler, Patrick, Twiss Butler, and Laurie Williams, (1988), Sex-Divided Mileage, Accident, and Insurance Cost Data Show That Auto Insurers Overcharge Most Women, *Journal of Insurance Regulation*, 6: Part I, 243-284 and Part II, 373-420. www.centspermilenow.org/Reprints/342.pdf

Casualty Actuarial Society (2001), *Foundations of Casualty Actuarial Sciences*.

Chiappori, Pierre-Andre, and Bernard Salanié, (2000), “Testing for Asymmetric Information in Insurance Markets,” *Journa1 of Politca1 Economy*, vol. 108, 56-78.

Cohen, Alma, (2004), “Profits and Market Power in Repeat Contracting: Evidence from the Insurance Market,” Analysis Group and Harvard Center for Law, Economics, and Business mimeograph.

Cohen, Alma, (2005), “Asymmetric Information and Learning: Evidence from the Automobile Insurance Market,” *The Review of Economics and Statistics*, vol. 87, pp. 197-207

Cohen, Alma and Liran Einav, (2005), "Estimating Risk Preferences from Deductible Choice," working paper, January 20, 2005

Cummins, J. David, (2001), "Property-Liability Insurance Price Deregulation: The Last Bastion?" 1-21, *Deregulating Property-Liability Insurance*, J. David Cummins, ed., American Enterprise Institute & Brookings Institution.

D'Arcy, Stephen P., and Neil A. Doherty, (1990), Adverse Selection, Private Information, and Lowballing in Insurance Markets, *Journal of Business* vol. 63, 145-164.

Delhomme, Patricia, (1991), Comparing One's Driving With Others': Assessment of Abilities and Frequency of Offences. Evidence For A Superior Conformity of Self-Bias? *Accident Analysis & Prevention* Vol. 23. No. 6. pp. 493-508.

Evans Leonard, (1999) Transportation Safety, *Handbook of Transportation Science*, R.W. Hall Editor, Kluwer Academic Publishers, Norwell, MA, 63-108

Finkelstein, Amy and James Poterba (2006) Testing for Adverse Selection with "Unused Observables", ms. March 2006. NBER

Harrington, Scott, and Greg Niehaus (1998), Race, Redlining, and Automobile Insurance Prices, *Journal of Business,* 71:439-469

Hu, Pat S. And Timothy R. Reuscher (2004), Summary Of Travel Trends, 2001 National Household Travel Survey, Fed. High. Admin., available at *http://nhts.ornl.gov/2001/pub/STT.pdf* , Table 1.

Jaffee, Dwight, and Thomas Russell, (1998), The Causes and Consequences of Rate Regulation in the Auto Insurance Industry, in David Bradford, ed., *The Economics of Property-Casualty Insurance*, 81-112.

Kofman, Paul and Gregory P. Nini (2006), Asymmetric Learning In Insurance Markets, in *Competitive Failures in Insurance Markets: Theory and Policy Implications*, edited by Pierre-André Chiappori and Christian Gollier. MIT Press, 283-313.

Lemaire, Jean, (1985), *Automobile Insurance*. Huebner International Series on Risk, Insurance and Economic Security, Kluwer Academic Publishers, Boston.

Lemaire, Jean, (1995), *Bonus-Malus Systems in Automobile Insurance*. Huebner International Series on Risk, Insurance and Economic Security, Kluwer Academic Publishers, Boston.

Lemaire, Jean (1997), *Insurance Regulation in Europe and the United States*, Huebner Foundation Monograph 16, Wharton School, university of Pennsylvania.

McNamara, Daniel J. (1987), Discrimination in Property-Liability Insurance Pricing, in ISSUES IN INSURANCE 1, 47 (Everett D. Randall ed., 4th Ed. 1987).

Miller, Michael, and Richard Smith (2003), The Relationship Between Credit-Based Insurance Scores to Private Passenger Automobile Insurance Loss Propensity. Bloomington, IL: Epic Actuaries, LLC. http://www.ask-epic.com/Publications/Relationship%20of%20Credit%20Scores_062003.pdf

Pinquet, Jean. 1998. Designing Optimal Bonus-Malus Systems from Different Types of Claims. *Astin Bulletin* 28:205-220.

Pinquet, Jean. (1999). Allowance for Hidden Information by Heterogeneous Models and Applications to Insurance Rating, in *Automobile Insurance: Road Safety, New Drivers, Insurance Fraud and Regulation*, edited by G. Dionne and C. Laberge-Nadeau. Kluwer Academic Publishers: 47-78.

Polinsky, A. Mitchell, (1989), *An Introduction to Law and Economics*, 3rd. Edition, New York: Aspen Publishers.

Pritchard, Tim, and Larry DeBoer, (1995), The Effects of Taxes and Insurance Costs on Automobile Registrations in the United States, Public Finance Quarterly, 23:283-304.

Posner, Richard A. (2003), *Economic Analysis of Law*, 6th ed., Aspen Publishers.

Puelz, Robert, and Arthur Snow, "Evidence on Adverse Selection: Equilibrium Signaling and Cross-Subsidization in the Insurance Market," *Journal of Political Economy* 102 (1994), 236–257.

Regan, Laureen. 2001. Determinants of the Selection of Full or Limited Tort Auto Insurance in Pennsylvania: An Empirical Analysis. In *The Economics and Politics of Choice No-Fault Insurance*, edited by E. L. Lascher, Jr. and M. Powers.

Schwartz, Gary T. (2000) Auto No-Fault and First-Party Insurance: Advantages and Problems; 73 Southern California Law Review 611

SRI International (1979), Choice of a Regulatory Environment for Automobile Insurance, Stanford, Ca. (Prepared for Commercial Union Assurance Companies, Boston, Ma.)

Svenson, Ola (1981), Are We All Less Risky And More Skillful Than Our Fellow Drivers? *Acta Psychologica* 47, 143-148

U.S. Congress, House Committee on the Judiciary, Antitrust Subcommittee (1967), Automobile Insurance Study, 165 pages.

Vickrey, William (1968), Automobile Accidents, Tort Law, Externalities, and Insurance: An Economist's Critique, *Law and Contemporary Problems*, 33:464-487. Reprinted with annotation at: www.vtpi.org/vic_acc.pdf

Walters, Michael A., 1981, Risk Classification Standards, *Proceedings of the Casualty Actuarial Society*, 68:1-18.

Williams, Allan, 1999, Licensing Policies for Young Drivers in the United States, in *Automobile Insurance: Road Safety, New Drivers, Risks, Insurance Fraud and Regulation*, edited by Georges Dionne and Claire Laberge-Nadeau, Kluwer Academic Publishers, Boston: 215-220.

Williamson., Oliver E., Douglas G. Olson, & August Ralston (1967), Externalities, Insurance, and Disability Analysis, 34 *Economica* 235.