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Testing for Offsetting Behavior and Adverse Recruitment Among Drivers of Airbag-Equipped Vehicles

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Abstract

Earlier studies reported that an insurance industry index of personal-injury claims rose after automobiles adopted driver's side airbags and that drivers of airbag-equipped vehicles were more likely to be at fault in fatal multivehicle accidents. These findings can be explained by the offsetting behavior hypothesis or by at-risk drivers systematically selecting vehicles with airbags (i.e., adverse recruitment). We test for offsetting behavior and adverse recruitment after airbag adoption using a database containing information on fatal accidents including information on drivers' previous records and drivers' actions that contributed to the occurrence of the accident. Further, we reexamine the personal injury claims index data for newly airbag-equipped vehicles and show that the rise in the index after airbag adoption may be attributable to moral hazard and a new vehicle ownership pattern. Rental car drivers are much more likely to commit grievous acts than other drivers, and the proportion of new automobiles in daily rental service more than doubled during the period of airbag adoption.

Introduction

For almost 30 years, a number of researchers have reported evidence that changes in driver behavior may mitigate some of the benefits expected from the adoption of automotive safety appliances. Recent evidence comes from Peterson and Hoffer (1994, 1996) who analyzed nationwide insurance industry statistics and found that adoption of an airbag results in higher personal injury claims and collision frequency for a vehicle line. Analysis of fault in fatal motor vehicle accidents in Virginia in 1993 (Peterson, Hoffer, and Millner, 1995) suggests that the driver of the vehicle equipped with an airbag is more likely to be at fault in a multiple-vehicle accident. One explanation for this evidence is offsetting behavior:[1] drivers, having self-insured by purchasing an

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[1] Also referred to as compensating behavior and risk compensation.

airbag, know that the loss in the event of an accident is lower and drive more aggressively as a result. Another explanation, having quite different policy implications, is that of "adverse recruitment": drivers who are at greater risk of an accident are more likely to self-insure by choosing airbag-equipped vehicles.

Adverse recruitment and offsetting behavior in the context of self-insurance carry implications concerning the choice to insure and potential changes in behavior after insuring that parallel those of adverse selection and moral hazard in the usual insurance situation, except that there is no asymmetric information problem as the insured and insurer are one. In a review of econometric models of insurance with asymmetric information, Chiappori (2000) notes that both adverse selection and moral hazard imply a correlation of risk and insurance coverage but imply causality running in different directions. Under adverse selection, different levels of risk cause individuals to select different insurance coverage, whereas under moral hazard, individuals make an insurance choice and then the existence of insurance changes the incentive for self-protective activities resulting in a change in the probability of an accident. Chiappori notes the difficulties involved in untangling the correlated risk and insurance coverage and reviews various strategies that have been applied; some of the difficulties arise from endogeneity of insurance pricing and experience rating as an omitted or misspecified variable (Chiappori, 2000; Dionne, Gouriéroux, and Vanasse, 2001). Study of the related concepts "adverse recruitment" and "offsetting behavior" in the case of self-insurance involves the same problem of untangling the reasons for the correlation of risk and (self) insurance coverage but avoids the complications introduced by contracting and asymmetric information.

We test for offsetting behavior and adverse recruitment resulting from airbag adoption using data from the U.S. Department of Transportation's Fatal Accident Reporting System (FARS) database that contains information on every motor-vehicle accident in the United States resulting in a fatality (National Highway Traffic Safety Administration, 1997). We undertake two tests—one analyzing the data on drivers' previous records and another analyzing drivers' grievous actions. The analysis of previous records allows a test distinguishing offsetting behavior and adverse recruitment by examining changes in drivers' records when a vehicle line adopts a driver's side airbag as standard equipment. If adverse recruitment occurs, then when at-risk drivers switch to airbag-equipped vehicles the average driver record for a vehicle line should deteriorate. If offsetting behavior occurs, then each subsequent year of ownership of the airbag-equipped vehicle should result in further deterioration in the average record of drivers in a vehicle line. The analysis of grievous driver actions, while not allowing us to distinguish offsetting behavior from adverse recruitment, does allow us to assess the extent of their joint impact. Similar to the analysis in Peterson, Hoffer, and Millner (1993), but with a sample size one hundred times larger, we examine changes in the probability of a driver committing a grievous act after a vehicle line adopts an airbag.

In the section "Self-Insurance and Self-Protection Among Motor Vehicle Drivers" we review evidence concerning self-insurance and self-protective behavior and findings concerning automobile safety appliances. We describe our tests and results in the section "The FARS Data and Our Tests of Offsetting Behavior and Adverse Recruitment." These findings lead us to reexamine the insurance industry data, and these findings are reported in the section "Reexamining Insurance Industry Personal-Injury-Loss Data." In the last section we draw conclusions.

SELF-INSURANCE AND SELF-PROTECTION AMONG MOTOR VEHICLE DRIVERS

Simple models of risk aversion yield the unambiguous conclusion that greater risk aversion implies greater levels of self-insurance (Dionne and Eeckhoudt, 1985), but the same is not true of self-protection. More risk-averse individuals do not necessarily expend more effort at self-protection, and a number of researchers have worked to characterize the conditions under which greater risk aversion implies greater levels of self-protection (Briys and Schlesinger, 1990; Jullien, Salanié, and Salanié, 1999; Chiu, 2000). Comparative statics results for self-protection are similarly limited to specific assumptions about the utility function (Sweeney and Beard, 1992). But one comparative static result for self-protection is unambiguous: a decrease in the probability of the hazard (which is the effect of self-insurance) implies a decrease in costly self-protection activities (Ehrlich and Becker, 1972).[2]

Peltzman (1975) presented an expected-utility model of driver behavior in which individuals engage in a level of self-protective activity, and argued that the predicted fatality-decreasing effects of vehicle safety regulations would be offset by changes in the level of self-protection. Peltzman analyzed time series data on fatality rates and concluded that occupant fatality rates improved much less than engineering estimates predicted and that nonoccupant (pedestrians, bicyclists, motorcyclists) fatality rates increased significantly. Peltzman's study prompted many researchers to examine the same or similar data. Blomquist (1988) reviews critically the succeeding studies examining the impact of the first motor vehicle safety regulations and concludes that the effect of the vehicle safety devices were partially offset by changes in driver behavior, but that the safety regulations decreased the overall fatality rate.

The advent of mandatory seat belt laws and the introduction of airbags have provided new grist for testing for the existence of offsetting behavior.[3] Use of seatbelts can be thought of as an act of self-insurance (albeit a small one) since use comes at some effort and seatbelts decrease the size of the loss in the event of an accident. Evidence that mandatory seatbelt laws have resulted in smaller than expected reductions in traffic fatalities has been taken as at least partially supportive of offsetting behavior (Evans, 1985; Evans and Graham, 1991). Conclusions about the extent of offsetting behavior, however, depend on estimates of the expected benefits of seatbelts to vehicle occupants, and differences between seatbelt users and nonusers complicate such estimates. Expected utility theory predicts that more risk-averse individuals should be more likely to use seatbelts, but also individuals who perceive themselves to be

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[2] And this holds as long as the marginal productivity of self-protection is nondecreasing in probability of a hazard.

[3] In addition to mandatory seatbelt laws and airbags, higher incidence of accidents with antilock brake-equipped vehicles has been offered as evidence of offsetting behavior (Evans, 1996). But Kahane (1994) argues that such accidents are caused by panic steering by drivers who are inexperienced with antilock brakes, and Harless and Hoffer (2002) provide evidence to support this conjecture showing that the antilock brake anomaly is confined largely to drinking drivers and is present only in the first few years of vehicle service.

at greater risk of being in an accident. Empirically, there is considerable evidence of the former: seatbelt users, even those adopting after implementation of mandatory seatbelt laws, tend to be safer drivers than nonusers and in less severe accidents than nonusers (Evans, 1985, 1996). For example, Dee (1998) reports that the impact of mandatory seatbelt laws on use rates was smaller on young drivers, male drivers, and drivers who reported themselves to be frequent or binge drinkers.

A parallel exists to results from recent carefully developed tests for the existence of adverse selection in automobile insurance markets that have yielded surprising negative conclusions. Chiappori and Salanié (2000) study young drivers in the French automobile insurance market and find no evidence of a correlation between the choice of contract (liability versus comprehensive insurance) and riskiness unobservable to the insurance company. Dionne, Gouriéroux, and Vanasse (2001) find that for a Canadian auto insurer there was no support for the prediction that higher-risk individuals choose lower deductibles within insurance company risk classifications. This evidence, contrary to received theory of adverse selection, led de Meza and Webb (2001) to develop a theory of advantageous selection that assumes that greater self-protection activity is undertaken by more cautious individuals who are also more likely to purchase insurance. The evidence on seatbelt use is consistent with the idea of advantageous, rather than adverse, recruitment.

During the period when buyers had a choice of new vehicles with and without airbags, purchase of a vehicle equipped with an airbag may be thought of as an act of self-insurance. Again, individuals more likely to self-insure by purchasing a vehicle with an airbag, are those that are either more risk-averse (advantageous recruitment) or perceive themselves to have a higher probability of an accident (adverse recruitment). Conditional on having the airbag that decreases loss in the event of an accident, there is a decrease in the incentive for self-protective activities for both of these types of self-insurers. Evidence exists of higher insurance injury claims for vehicle lines adopting a driver's side airbag as standard equipment. Peterson and Hoffer (1994, 1996) and Peterson, Hoffer, and Millner (1995) analyze personal injury claims index data from the Highway Loss Data Institute and show that vehicle lines that adopted airbags in 1990 and 1992 incurred approximately 7 percent higher relative personal injury insurance claims in the initial year of airbag adoption. Peterson and Hoffer (1996) report a similar finding for a Highway Loss Data Institute index of collision frequency. Of greater impact than the insurance industry claims data was the analysis of police accident reports for fatal two-vehicle accidents involving one airbag-equipped automobile occurring in Virginia in 1993 (Peterson, Hoffer, and Millner, 1995). In 22 out of a total 30 such accidents, the airbag-equipped vehicle was found to have initiated the accident; under the null hypothesis of equal fault probabilities, 22 or more accidents in which the airbag-equipped vehicle was at fault would have occurred with probability 0.008. But these analyses of insurance industry data and fatal accidents after airbag adoption do not address the question of whether these effects are attributable to offsetting behavior or adverse recruitment. In their study of the effectiveness of airbags and seatbelts, Levitt and Porter (2001) provide some evidence of advantageous recruitment with airbags: in their sample, a simple comparison of drivers of vehicles with and without airbags indicates that drivers of vehicles without airbags were less likely to have had a recent speeding ticket, accident, license suspension, or DWI conviction, and were less likely to be a male or under age 25.

THE FARS DATA AND OUR TESTS OF OFFSETTING BEHAVIOR AND ADVERSE RECRUITMENT

The FARS database contains detailed information characterizing the vehicle accident (e.g., the number of vehicles involved, the number of passengers in each vehicle), information on the age and sex of each person involved in the accident, the driver's vehicle record in the prior 3 years, and specific acts taken by the driver of each vehicle that contributed to the accident. In addition, the database includes vehicle identification numbers so that the make, model, model year, and such other information may be obtained. We study the 1991–1997 accident data from FARS for a sample of vehicles that adopted a driver's side airbag in the 1992 to 1995 model years.[4] By 1995, nearly all new automobiles and minivans had a driver's side airbag as standard equipment. Originally, we hoped to include vehicle lines that adopted airbags prior to 1992, but in order to best implement the proposed tests we must use vehicle ownership information, especially distinguishing rental vehicles. The FARS database, however, does not include a means to identify vehicle ownership until 1991. Since we compare vehicle lines before and after airbag adoption, we can only include vehicle lines that switched to a driver's side airbag in 1992 or after.[5]

Our sample is based on 63 automobile and minivan vehicle lines that had production of at least 15,000 units for the U.S. market (Crain Communications, 1990–1996) in the year prior to and in the year the vehicle line adopted a driver's side airbag as standard equipment. We treat different body-styles (two-door sedan, four-door sedan, convertible, station wagon) as separate vehicle lines so, for example, four-door Toyota Tercels and two-door Toyota Tercels are two separate vehicle lines. For each vehicle line, we track up to three model years before and after a driver's side airbag became standard equipment. For example, the Toyota Tercel four-door sedan carried a driver's side airbag as standard equipment starting with the 1993 model year: subject to the restriction that vehicle ownership information is only available starting with the 1991 FARS data, we study accidents for this vehicle line in the three model years prior to airbag adoption (model years 1990–1992) and the first three model years after airbag adoption (model years 1993–1995). And for each model year, we consider all accidents that occur involving vehicles in up to their first 3 years of service; for example, for a 1993 model year vehicle we consider accidents occurring from its introduction through, at most, the end of the 1995 calendar year.[6] To illustrate, Table 1 indicates the model years and calendar years included in the sample for a vehicle line adopting an airbag in 1993.

[4] There were 13 vehicle lines that offered an optional driver's side airbag in the year prior to adopting the airbag as standard equipment; we include these vehicle lines in our sample but exclude the data from the year in which the airbag was optional. We excluded four other vehicle lines that offered an optional driver's side airbag for 2 or more years prior to adopting the airbag as standard equipment. Analyzing only vehicles that had an optional airbag would seem a promising alternative to the approach we use, but sample size is an impediment. If we were to restrict analysis to the vehicles with an optional driver's side airbag our sample size would decrease from 6,000 to 225.

[5] Our conclusions are unchanged, however, if we include vehicles that adopted an airbag starting in 1989 but do not distinguish drivers of rental vehicles.

[6] Actually, the period is approximately 3 years and 3 months since the introduction of, for example, 1993 model-year vehicle would typically occur in October of 1992.

TABLE 1
Model Years and Calendar Years Included in the Sample for a Vehicle Line Adopting a Driver's Side Airbag as Standard Equipment in the 1993 Model Year

Model	Calendar Year							
Year	1990	1991	1992	1993	1994	1995	1996	1997
1990	–[a]	No airbag	No airbag					
1991		No airbag	No airbag	No airbag				
1992			No airbag	No airbag	No airbag			
1993				Airbag	Airbag	Airbag		
1994					Airbag	Airbag	Airbag	
1995						Airbag	Airbag	Airbag

[a]Accidents occurring in calendar year 1990 are excluded because the FARS database does not include information on vehicle ownership (e.g., rental vehicles).

The FARS database covers only accidents in which there is at least one fatality and so is subject to a selection bias (Levitt and Porter, 2001). Cautious drivers and drivers who always wear seatbelts are less likely to be in a fatal accident, and hence less likely to be included in FARS. An airbag should decrease the chance of a fatality; hence, some drivers, say at-risk drivers who switch to an airbag-equipped vehicle, who would have otherwise died (causing the accident to be included in FARS) instead lived, causing the accident to be excluded from FARS. Levitt and Porter (2001) describe a simple solution to contend with this selection bias: consider only the cases where one or more fatalities occur in other motor vehicles or among nonmotorists involved in an accident. Suppose drivers of airbag-equipped cars drive more aggressively, any expected increase in own-vehicle deaths due to increased aggression will be ameliorated by the presence of the airbag, which may save the life of the driver of the airbag-equipped vehicle, causing the accident to be excluded from FARS. But this selection bias can be avoided by only considering FARS cases where fatalities occur *outside* the airbag-equipped vehicle and comparing driver records and the incidence of aggressive behavior by drivers before and after the vehicle line carries a driver's side airbag.

Information on the previous record of drivers and on grievous driver behavior may be gleaned from FARS to test for adverse recruitment and offsetting behavior. We describe the tests and results in the next two subsections.

A Test Based on the Previous Record of Drivers

The ideal test of adverse recruitment and offsetting behavior with airbag-equipped vehicles would involve a data set allowing us to observe the record of previous driving violations and accidents of individual drivers over time. Assume for the moment that adverse recruitment occurs but not offsetting behavior. Under adverse recruitment, when the time to purchase a new vehicle comes, individual drivers who are at greater risk of an accident are more likely to self-insure by choosing a vehicle with an airbag despite its higher cost.[7] The driving record of the individual is unchanged, but they

[7] Mannering and Winston (1995) estimate the marginal cost to consumers of a driver's side airbag to be $300.

have switched vehicle lines. Conditioning on the individual drivers, we would see no systematic difference in driving records when individuals switch vehicles. But conditioning on the vehicle line, the record of the average driver in the vehicle line would worsen with airbag adoption.

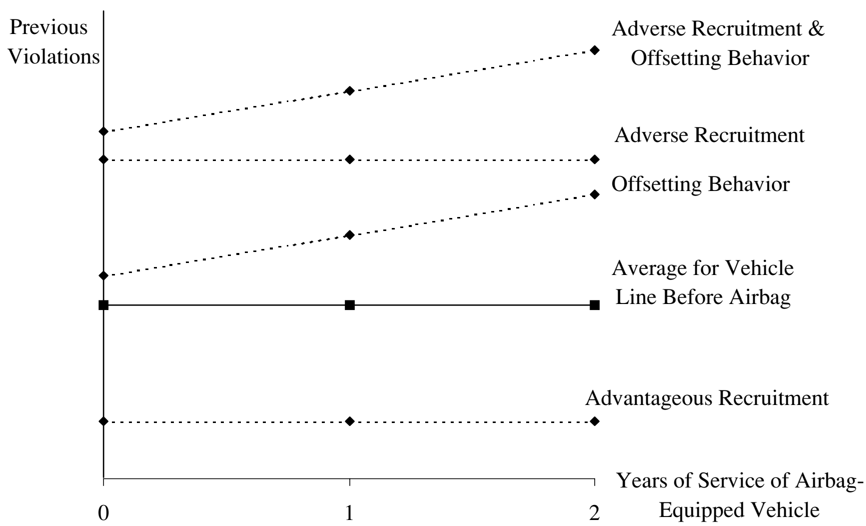
Unfortunately, this ideal data set is not available to us. Yet, using the FARS data we can construct a test using this logic, which tracks vehicle lines over time. For each driver involved in a fatal accident, FARS contains information on the number of previously recorded driving-while-under the influence (DWI) convictions, driver's license suspensions, speeding tickets, and motor vehicle accidents in the 3 years prior to a fatal accident. If individuals at higher risk of an accident tend to switch to vehicle lines with an airbag, then the record of the average driver in these vehicle lines should worsen: comparing the preairbag and postairbag models in the same vehicle line, we should observe drivers with higher numbers of previous convictions and accidents.

Now assume offsetting behavior occurs. For those individuals having purchased an airbag-equipped vehicle, the existence of the airbag changes the incentive for self-protection so that individuals would be expected to have more accidents and driving violations. In the ideal database that tracked individuals, the switch to the airbag-equipped vehicle would imply a driving record that would deteriorate with each passing year as the driver accumulated more driving violations and accidents. Again, we do not have that ideal database, but we do observe the previous records of drivers before and after airbag adoption: conditioning on vehicle lines, after airbag adoption the average driver record for a vehicle line should deteriorate over time.

Figure 1 illustrates the test by showing several possible patterns of changes in the number of previous violations (or accidents) for drivers of vehicle lines adopting a

FIGURE 1

Pattern of Previous Violations (or Accidents) Implied by the Adverse Recruitment, Advantageous Recruitment, and Offsetting Behavior Hypotheses



driver's side airbag. The horizontal axis indicates the vehicle's years of service after adoption of an airbag; zero represents the first year the vehicle is in operation. The solid horizontal line indicates the average number of previous driver violations (or accidents) for the vehicle line before airbag adoption—the baseline from which we measure possible changes in the average driver record to test for adverse or advantageous recruitment and offsetting behavior.[8] Deterioration in the average record of drivers in the vehicle line after adoption of a driver's side airbag is represented in the figure by the dotted horizontal line labeled "Adverse Recruitment." Of course, the opposite can occur: more safety conscious drivers might systematically choose vehicles with airbags as suggested by Levitt and Porter (2001). Advantageous selection is represented in the graph by another dotted horizontal line lying below the baseline. Obviously, adverse recruitment and advantageous recruitment may occur for different drivers and our empirical model attempts to get at the net effect of these two selection effects.

For accidents occurring in the first year of a vehicle's life (with at least 2 years of the 3-year record having been established in the driver's earlier vehicle), a driver's previous record as reflected in FARS is most influenced by the record in his or her *previous* vehicle. But as the vehicle ages, the driver's 3-year record reported in FARS comes to reflect the driver's traffic violation history in the present vehicle. If offsetting behavior occurs, then the average driver record for the vehicle line will deteriorate as the 3-year previous record comes to reflect the driver's history in the airbag-equipped vehicle. Hence, we test for offsetting behavior by looking for change in driver records as the period of ownership lengthens. In Figure 1, this is represented by an increase in the number of violations as the years of service of the airbag-equipped vehicle increases.[9]

Consistent with the approach we have outlined, our specification should reflect differences in average driver records across vehicles lines. In explaining Figure 1, we made reference to the baseline of previous violations or accidents before airbag adoption, but this baseline can be quite different across vehicle lines. For example, consider the Saturn four-door sedan and the Hyundai Elantra four-door sedan, both of which are in the same small car consumer "market class" (Crain Communications, 1995). In our sample, both cars have the same proportion of male drivers aged 26–35; but 5 of 12 such Elantra drivers have one or more suspensions on their previous record whereas none of the 21 Saturn drivers have previous suspensions (difference significant at $P = 0.003$ in Fisher's Exact test). Differences of this kind by vehicle line are common. Hence, to implement the proposed test we incorporate fixed effects for the vehicle line because a driver's choice of vehicle can be an important way to capture heterogeneity.

We assume that conditional on the existence of a driver's side airbag, the age and sex of the driver, the years of service of the vehicle, the years of service of the airbag

[8] In drawing Figure 1 we assume that, absent offsetting behavior, the number of violations is independent of the years of service of the vehicle. Below, our specification allows for a change in the number of previous violations as the vehicle ages.

[9] Of course, advantageous recruitment and offsetting behavior can occur as well, but we do not include this possibility in Figure 1 to avoid complicating the figure.

equipped vehicle, and calendar year-specific effects, the number of previous accidents or traffic violations of a particular type in the record of drivers operating a vehicle in line i in year t, n_{it}, is Poisson-distributed with a vehicle line-specific effect α_i:

$$E[n_{it} \mid \alpha_i, Airbag_i, Years\ Service_{it}, x_{it}] = \alpha_i \exp\{\beta_1 Airbag_i + \beta_2 Years\ Service_{it} + \beta_3 Airbag_i * Years\ Service_{it} + \theta_t + \gamma \boldsymbol{x}_{it}\}, \quad (1)$$

where *Airbag* is a dummy variable equal to 1 for an airbag equipped vehicle, *Years Service* indicates the number of years of service for the vehicle (beginning with 0 for a new vehicle), θ_t is a calendar year-specific effect, and $\boldsymbol{x}_{it}$ represents a vector of dummy variables indicating the sex and age of the driver. Recalling the test illustrated in Figure 1, adverse recruitment is indicated if $\beta_1 > 0$: that is, controlling for vehicle line-specific effects and driver age and sex, riskier drivers select the airbag-equipped vehicle, increasing the average level of traffic violations relative to drivers of preairbag vehicles. Advantageous selection is indicated if $\beta_1 < 0$. Offsetting behavior is indicated if $\beta_3 > 0$: again controlling for vehicle line-specific effects and driver age and sex, the longer the driver operates the airbag-equipped vehicle, the higher the number of previous traffic violations if drivers are more aggressive as a result.

The test we propose examines changes in the number of violations by the same driver and requires that, in the main, the same driver/household maintains ownership of a vehicle over the period considered. Hence, we must consider how many years of service to include in our test. Figure 1 illustrates the predictions of the two hypotheses over the first 3 years of service. But some changes in vehicle ownership occur over a 3-year period: 98.8 percent of originally purchasing households keep their newly purchased cars 2 years or more, whereas 83.1 percent keep their new cars 3 years or more (American Automobile Manufacturers Association, 1997). Using 3 years of service provides the more powerful test of the hypotheses—particularly of the offsetting behavior hypothesis—as long as the quality of the tests is not degraded by changes in ownership that bias the coefficient estimates. We report results using the sample entailing the first 3 years of service; but, as we note in footnote 13, results using the first 2 years of service are very similar and lead to the same conclusions about offsetting behavior and recruitment effects.[10]

[10] Although we exclude rental vehicles (as well as a small number of unregistered vehicles), we pool vehicles registered as business or government vehicles with vehicles registered to private individuals. In 1992, 190,000 new automobiles were placed in commercial and government service compared to 1,645,000 placed in rental service (*Automotive News*, March 22, 1993, p. 55; *Used Car Market Report*, 1998, p. 17). Most nonrental fleet automobiles are assigned to an individual who, while not having all the rights of ownership, bears considerable responsibility for the vehicle. For example, the individual must explain to their employer losses from accidents or excessive wear and tear. Further, most private fleet plans give the assignee the option to purchase their vehicle at a predetermined fixed price. Assignees often choose their fleet vehicle with the intent of purchasing it eventually for their personal use or to resell at a profit. Below, we test for grievous actions on the part of drivers and find that drivers of vehicles registered to businesses or governments, unlike rental vehicles, are no more likely to commit grievous acts than private owners (see footnote 16).

Table 2 contains summary statistics and additional information on all the variables used in the test described in this section as well as additional variables used in the subsequent section. Table 3 contains the estimation results for Equation (1) for each of four elements of a driver's previous record. Note that a maximum number of 63 vehicle lines may be included in the analysis, but the number of vehicle lines that is effectively included depends on the existence of at least one nonzero count in the vehicle line (lines with zero counts do not affect the likelihood function). For example, there were 25 vehicle lines in which we observe no DWI convictions *before or after* the adoption of a driver's side airbag, and so information from the remaining 38 vehicle lines determine the coefficient estimates for this equation. The tables include a chi-squared statistic testing the overall significance of the regressors exclusive of the dummy variables for vehicle lines.

The age and sex dummy variables are all measured relative to female drivers between the ages of 46 and 65. For example, for the previous suspensions equation the coefficient for the *Driver Under Age 26* dummy variable is 1.230 implying the conditional mean is 3.4 (=exp(1.230)) times larger for a female driver under the age of 26 compared to a female driver between the ages of 46 and 65 (a 240 percent increase in the conditional mean). The age and sex dummy variables are often significant, especially for the dummy variables for younger and male drivers in the equations describing previous suspensions, speeding tickets, and accidents.

The estimated coefficient for the *Airbag* variable for previous DWI convictions, 2.131 ($z = 3.30$), indicates strong evidence of adverse recruitment implying a 740 percent increase (=exp(2.131) −1) in the conditional mean. Although there is strong evidence of adverse recruitment for previous DWI convictions, in the other three equations the estimated coefficients for the *Airbag* variable are negative, suggesting advantageous recruitment. But the *Airbag* coefficient is statistically significant at conventional significance levels only in the previous suspensions equation where the coefficient estimate of −0.456 ($z = -2.38$) indicates a 37 percent decrease in the conditional mean of previous suspensions after the switch to airbags. These results are indicative of driver heterogeneity: the degree and direction of the recruitment effect depends on the type of violation.[11]

We detect strong evidence of adverse recruitment for DWI convictions, but our results provide no support for the offsetting behavior hypothesis which implies more violations as the number of years of service increases after airbag adoption. The results in Table 3 give no sign of increased violations; rather, the coefficients are negative and statistically significant at conventional significance levels for the previous DWI convictions and previous suspensions equations. That is, there is some evidence of improvement in driver record as the vehicle ages and the driver's record comes to reflect

[11] Note that the *Airbag* coefficient in the previous suspensions equation has a *P*-value of 0.017, but the weight attached to the conclusion concerning statistically significant advantageous recruitment is limited by the large sample size. Both Classical (Pitman, 1965; Aitkin, 1991) and Bayesian (Schwarz, 1978; Leamer, 1978) statistical theories suggest that the chosen significance level should decrease as sample size increases. For example, the Schwarz model selection criterion would select the model incorporating an airbag dummy variable over a model omitting it in the previous DWI equation, but not in the previous suspensions equation.

TABLE 2

Summary Statistics for the Full Sample: Driver and Vehicle Characteristics for Vehicle Lines Adopting a Driver's Side Airbag as Standard Equipment in the 1992–1995 Model Years

	Mean	Standard Deviation
Variables used in the section		
"A Test Based on the Previous Record of Drivers"		
Previous DWI Convictions[a]	0.013	0.138
Previous Suspensions[a]	0.126	0.802
Previous Speeding Tickets[a]	0.318	0.722
Previous Accidents[a]	0.188	0.498
Airbag[b]	0.549	0.498
Years Service[c]	1.087	0.785
Airbag ∗ Years Service	0.568	0.773
Driver Under Age 26[b]	0.266	0.442
Male Driver Under Age 26[b]	0.143	0.350
Driver Age 26–35[b]	0.267	0.443
Male Driver Age 26–35[b]	0.138	0.345
Driver Age 36–45[b]	0.211	0.408
Male Driver Age 36–45[b]	0.109	0.312
Male Driver Age 46–65[b]	0.105	0.307
Driver Over Age 65[b]	0.073	0.260
Male Driver Over Age 65[b]	0.047	0.212
Additional variables used in the section		
"A Test Based on the Grievous Actions of Drivers"		
Passengers[d]	1.735	1.116
Passengers ∗ Driver Under 26	0.460	0.943
Driver Drinking[b,e]	0.080	0.272
Rental Vehicle[b]	0.052	0.222
Grievous Driver Action[b,f]	0.219	0.414

Notes: Information on driver's side airbag as standard equipment used to construct the Airbag dummy variable comes from *Consumer Reports*, *Automotive News Market Data Books*, and various publications of the Insurance Institute for Highway Safety. All other variables are constructed using information from the FARS database.

[a]For drivers involved in a fatal accident, the FARS database includes information on the number of driving violations (accidents) that occurred in the 3 years prior to the date of the fatal accident.

[b]Dummy variable.

[c]Variable indicates the number of years of vehicle service, beginning with zero for the first year of vehicle service.

[d]Total number of passengers in the vehicle, including the driver.

[e]Dummy variable equal to one if the investigating police officer reported that the driver was drinking or there was a positive alcohol test for the driver.

[f]*Grievous Driver Action* is equal to one if any of the following conditions was indicated as present in the FARS database: Driving on wrong side of road; Driving too fast for conditions or in excess of posted speed limit; Driving wrong way in one-way trafficway; Failure to comply with physical restrictions of license; Failure to obey traffic signs, traffic control devices or traffic officers, failure to observe safety zone traffic laws; Failure to yield right of way; Getting off/out of or on/in to moving vehicle; High-speed chase with police in pursuit; Illegal driving on road shoulder, in ditch or sidewalk, or on median; Improper or erratic lane changing; Making improper entry to or exit from trafficway; Making right turn from left turn lane or making left turn from right turn lane; Nontraffic violation charged–manslaughter or other homicide offense; Opening vehicle closure into moving traffic or while vehicle is in motion; Operating at erratic or suddenly changing speeds; Operating the vehicle in an erratic, reckless, careless or negligent manner or operating at erratic or suddenly changing speeds; Passing on wrong side; Passing where prohibited by posted signs, pavement markings, hill or curve, or school bus displaying warning not to pass; Passing with insufficient distance or inadequate visibility or failing to yield to overtaking vehicle.

his or her history in the airbag-equipped vehicle.[12] Our conclusions are unchanged if we use the first 2 years of vehicle service instead of the first 3 years.[13] Acknowledging the limitations of not having the ideal data set described at the beginning of this subsection and not having exogenous assignment of drivers to vehicles, these and alternate specifications using data on driver records in vehicle lines adopting airbags provide no support for the offsetting behavior hypothesis.[14]

Finally, we note the importance of vehicle-line fixed-effects for a proper specification of the counts of previous violations. We can compare, using a likelihood ratio chi-squared statistic, the model in Equation (1) to a model that assumes a common intercept for all vehicle lines. The null hypothesis that the fixed effect coefficients equal zero is rejected resoundingly for previous suspensions ($\chi^2 = 263.5$, $df = 60$, $P = 2.5\text{E-}27$) and for previous speeding tickets ($\chi^2 = 106.1$, $df = 62$, $P = 0.0004$). The null hypothesis cannot be rejected, however, for the previous DWI convictions ($\chi^2 = 35.3$, $df = 37$, $P = 0.55$) and previous accidents ($\chi^2 = 56.6$, $df = 62$, $P = 0.67$) equations.

A Test Based on the Grievous Actions of Drivers

Peterson, Hoffer, and Millner (1995) examine the 30 two-vehicle fatal accidents that occurred in Virginia in 1993 and find that the driver of the airbag-equipped vehicle was much more likely to be at fault. Using the FARS database, we are able to undertake a similar test but with a sample size 100 times larger. Specifically, FARS contains

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12 This result is puzzling, and we can only offer the following speculation: Perhaps some drivers react to a DWI conviction by realizing they are at greater risk and subsequently both self-insure and drive more cautiously.

13 For example, using 2 years of service in the previous DWI convictions equation, the coefficient for *Airbag* is 2.768 (z = 3.24), which is larger than the coefficient of in Table 3. Using 2 years of service, the coefficient for *Airbag* $*$ *Years Service* is -1.381 ($z = -1.91$); this coefficient is larger than the coefficient in Table 3 but is measured less precisely, which is expected given one fewer year of service.

14 We considered two other specifications as well, and these are reported in an unpublished appendix to this article, available at http://www.bus.vcu.edu/economics/harless. In Table A1, we consider a model without fixed effects for vehicle line. In the absence of fixed effects we estimate coefficients with less precision, which is not surprising since we go from a situation of estimating a baseline level of violations/accidents for each vehicle line to a situation where we estimate the same baseline for all vehicles. The signs of the coefficients for *Airbag* and *Airbag* $*$ *Years Service* are the same as in Table 3. The size of the *Airbag* $*$ *Years Service* coefficients are essentially the same as in Table 3, but the estimated coefficients for *Airbag* in the previous DWI equation (0.687, z = 1.42) and previous suspensions equation (-0.192, $z = -1.2$) are considerably smaller than the coefficients in Table 3. Further, in Table A2, we consider a fixed effects model but exclude data for any vehicle line if the physical characteristics of the vehicle changed (Crain Communications, 1990–1997) at the time of, or after the time of, airbag adoption. Recall that in constructing the sample we include three model years of a vehicle line after airbag adoption; in this restricted sample we exclude vehicle lines if there was any redesign or styling change—even a change as minor as a new grill. Coefficient estimates in Table A2 are essentially the same as in Table 3, but the coefficient for *Airbag* is larger in absolute value for the previous DWI convictions and previous suspensions equations.

TABLE 3
Analysis of Counts of Previous Driving Violations and Accidents for Drivers in Vehicle Lines Adopting a Driver's Side Airbag as Standard Equipment in the 1992–1995 Model Years

	Previous DWI Convictions	Previous Suspensions	Previous Speeding Tickets	Previous Accidents
Airbag	2.131***	−0.456*	−0.009	−0.156
	(0.646)	(0.191)	(0.121)	(0.159)
Years Service	0.903***	−0.110	0.109*	−0.054
	(0.282)	(0.086)	(0.053)	(0.072)
Airbag ∗ Years Service	−1.039**	−0.236*	−0.021	0.126
	(0.358)	(0.104)	(0.065)	(0.085)
Driver Under Age 26	−0.095	1.230***	0.503***	0.576***
	(0.881)	(0.294)	(0.136)	(0.163)
Male Driver Under Age 26	1.258*	1.150***	0.628***	0.220*
	(0.561)	(0.134)	(0.083)	(0.106)
Driver Age 26–35	0.787	0.949**	0.567***	0.249
	(0.797)	(0.300)	(0.134)	(0.168)
Male Driver Age 26–35	0.153	1.186***	0.511***	0.373**
	(0.469)	(0.152)	(0.084)	(0.121)
Driver Age 36–45	0.857	0.319	0.256	0.425*
	(0.809)	(0.340)	(0.146)	(0.169)
Male Driver Age 36–45	1.008*	1.369***	0.445***	−0.078
	(0.448)	(0.235)	(0.114)	(0.140)
Male Driver Age 46–65	1.151	0.389	0.280	0.324
	(0.795)	(0.337)	(0.145)	(0.174)
Driver Over Age 65	−0.866	−0.866	−0.763*	0.150
	(1.232)	(0.523)	(0.324)	(0.261)
Male Driver Over Age 65[a]			0.425	0.291
			(0.352)	(0.263)
Fixed Effects for Vehicle Line	×	×	×	×
Fixed Effects for Years	×	×	×	×
Number of Observations	4,454	5,939	6,021	5,928
Number of Vehicle Lines	38	61	63	63
Test of Overall Significance[b]				
Chi-Squared Statistic	44.5	406.5	294.6	55.1
Degrees of Freedom	17	17	18	18
P-value	0.0003	8.0E-76	6.1E-52	1.2E-5

*Significant at the 5% level; **significant at the 1% level; ***significant at the 0.1% level.
[a]There were no previous DWI convictions or license suspensions for females over 65 observed in the sample so we could not estimate a separate coefficient for males and females in these two circumstances.
[b]Test of overall significance of the regressors listed in the table (not including the dummy variables for vehicle lines).

information on the presence of 94 driver actions that may have contributed in some manner to the accident. These contributing factors range from "operating the vehicle in an erratic, reckless, careless or negligent manner or operating at erratic or suddenly changing speeds," to "improper tire pressure." We selected 19 of the 94 factors indicating aggressive or dangerous driving; the 19 factors are included in the notes to Table 2.[15] We refer to these as grievous actions. Conditioning on the vehicle line, the sex, age, and previous record of the driver, whether the driver is renting the vehicle, and circumstances of the accident (including whether the driver was reported to have been drinking), we test whether there is an increase in the probability of a driver committing a grievous action after the vehicle line adopts a driver's side airbag. Though this analysis cannot distinguish adverse recruitment and offsetting behavior, it does allow a way to gauge their joint impact in a large sample.

Let y^*_{it} be an index variable reflecting the likelihood of a driver operating a vehicle in line i committing a grievous act in year t; $y_{it} = 1$ (the driver commits a grievous act) if $y^*_{it} > 0$, $y_{it} = 0$ otherwise. We assume that y^*_{it} includes a fixed effect, represented by π_i, for the vehicle line. Given the fixed effects, we apply conditional logit (Chamberlain, 1980) to estimate the model

$$\begin{aligned} y^*_{it} = {} & \pi_i + \delta_1\, Airbag_i + \delta_2\, Years\ Service_{it} + \delta_3\, Passengers_{it} \\ & + \delta_4\, Passengers^*_{it}\ Driver\ Under\ 26_{it} + \delta_5\, Driver\ Drinking_{it} \\ & + \delta_6\, Rental_{it} + \theta_t + \mathbf{z}_{it}\boldsymbol{\lambda} + \mathbf{x}_{it}\boldsymbol{\eta} + \varepsilon_{it}. \end{aligned} \tag{2}$$

The variables *Airbag*, *Years Service*, and $\mathbf{x}_{it}$ are defined as above for Equation (1), $\mathbf{z}_{it}$ is a vector describing the previous record of the driver, and ε_{it} is an error term assumed to follow a logistic distribution. *Passengers* indicates the total number of passengers in the vehicle; 57 percent of the vehicles in our sample carry only the driver, but the number of passengers ranges up to 10. Evans and Wasielewski (1983) show that risky behaviors such as close following on a freeway decreases with the number of passengers in a vehicle. But the opposite holds for youthful drivers: risky driving tends to increase with the number of passengers (Chen et al., 2000). Hence, we include the interaction variable allowing for a different coefficient for drivers under the age of 26. *Driver Drinking* represents a dummy variable equal to one if the investigating police officer reported that the driver was drinking or there was a positive alcohol test for the driver. *Rental* represents a dummy variable equal to one if the vehicle was registered as a rental vehicle.

In Table 4 we report the coefficient estimates and marginal effects. A number of conclusions follow immediately. First, drinking alcohol has a tremendous affect on the probability of a driver committing a grievous act: the probability of a grievous act increases by 0.364 (coefficient $= 1.679$, $z = 16.3$). Second, a larger number of passengers decreases significantly the probability of a grievous act for most drivers ($z = -5.74$),

[15] We excluded factors that are less important (e.g., improper tire pressure) and items whose interpretation depends on the particular circumstances of the accident. For example, "Failure to keep in proper lane or running off road," cannot be interpreted as necessarily representing aggressive or dangerous driving when another involved vehicle passed with insufficient distance or inadequate visibility or failed to yield to an overtaking vehicle.

TABLE 4

Conditional Logit Analysis of Grievous Driver Actions for Vehicle Lines Adopting a Driver's Side Airbag as Standard Equipment in the 1992–1995 Model Years

	Full Sample	Marginal Effect	Subsample	Marginal Effect
Airbag	−0.073	−0.012	−0.064	−0.009
	(0.134)		(0.156)	
Years Service	−0.049	−0.008	−0.049	−0.007
	(0.058)		(0.067)	
Passengers	−0.254***	−0.041	−0.221***	−0.031
	(0.044)		(0.049)	
Passengers ∗ Driver Under 26	0.316***	0.051	0.313***	0.044
	(0.067)		(0.077)	
Driver Drinking	1.679***	0.364		
	(0.103)			
Rental Vehicle	0.437**	0.079	0.536***	0.089
	(0.143)		(0.169)	
Previous DWI Convictions	−0.033	−0.005		
	(0.214)			
Previous Suspensions	0.094**	0.015		
	(0.036)			
Previous Speeding Tickets	0.026	0.004	−0.022	−0.003
	(0.044)		(0.108)	
Previous Accidents	0.028	0.004	0.083	0.012
	(0.063)		(0.115)	
Driver Under Age 26	0.238	0.040	0.273	0.041
	(0.189)		(0.208)	
Male Driver Under Age 26	0.242*	0.041	0.218	0.033
	(0.114)		(0.131)	
Driver Age 26–35	0.203	0.033	0.152	0.023
	(0.162)		(0.175)	
Male Driver Age 26–35	0.012	0.020	−0.006	−0.001
	(0.131)		(0.157)	
Driver Age 36–45	0.019	0.003	−0.071	−0.010
	(0.173)		(0.188)	
Male Driver Age 36–45	0.116	0.019	0.038	0.005
	(0.154)		(0.184)	
Male Driver Age 46–65	0.070	0.011	−0.086	−0.012
	(0.170)		(0.185)	
Driver Over Age 65	0.714***	0.135	0.719**	0.123
	(0.223)		(0.228)	
Male Driver Over Age 65	−0.417	−0.059	−0.500*	−0.061
	(0.235)		(0.243)	
Fixed Effects for Years	×		×	
Number of Observations	6,195		4,991	
Number of Vehicle Lines	63		63	
Test of Overall Significance				
Chi-squared Statistic	482.5		149.5	
Degrees of Freedom	25		22	
P-value	3.2E-86		3.5E-33	

Notes: Coefficient estimates are obtained using the conditional logit model (Chamberlain, 1980) which assumes fixed effects for vehicle lines, but the coefficient estimates are not equivalent to logit with dummy variables for vehicle lines.

*Significant at the 5% level; **significant at the 1% level; ***significant at the 0.1% level.

but not for young drivers where additional passengers increases slightly the probability of a grievous act ($z = 4.72$). Third, drivers who have had one or more license suspensions in the previous 3 years are much more likely to commit a grievous act ($z = 2.63$). The coefficients for other types of previous violations and accidents are not statistically significant. Fourth, the coefficients for the driver age and sex dummy variables imply large marginal effects, but the standard errors of the coefficients are also relatively large. The coefficient for the dummy variable for drivers over age 65, however, is highly significant ($z = 3.20$). Fifth, drivers of rental vehicles are much more likely to commit a grievous act ($z = 3.06$).[16]

Finally, consider the coefficient for the *Airbag* dummy variable. The results in Peterson, Hoffer, and Millner (1995) would suggest a coefficient that was positive and statistically significant, but instead we obtain a coefficient that is negative and insignificant. Because some evidence of recruitment effects was detected in the previous section, we also consider results for a subsample that excluded some drivers. Drivers with previous DWI convictions or suspensions were excluded as well as drivers with two or more previous accidents or speeding tickets. Further, we exclude cases in which the investigating police officer reported that the driver was drinking or there was a positive alcohol test for the driver. As shown in Table 4, the results for the subsample are essentially unchanged from those for the full sample. Further, recall that we limited the sample to vehicles adopting airbags in the 1992–1995 model years because the FARS database began to report ownership information (e.g., rental vehicle) in 1991. In results available in an unpublished appendix, we add 34 vehicle lines that adopted driver's side airbags in model years 1989–1991. Though we are unable to distinguish rental vehicles in this sample, the conclusions reached, including conclusions concerning the *Airbag* dummy variable, are the same as those reached from Table 4.[17] Hence, contrary to the finding in Peterson, Hoffer, and Millner (1995) based on a very small number of accidents, when we control for the age, sex, previous record, condition of the driver, number of passengers, and vehicle line-specific effects, we find that drivers in a vehicle line are no more likely to commit a grievous act contributing significantly to a fatal accident after the vehicle line adopts a driver's side airbag.

REEXAMINING INSURANCE INDUSTRY PERSONAL INJURY LOSS DATA

Recall that the Highway Loss Data Institute index of personal injury claims increased significantly for vehicle lines in the year following airbag adoption, and that this

[16] Recall that we pool drivers of vehicles registered to businesses and governments with drivers of privately owned vehicles because the property rights are similar (footnote 10). We find no evidence that drivers of vehicles registered to businesses or governments are more or less likely to commit a grievous act. For example, if we add a dummy variable for business or government registered vehicles we estimate a coefficient of -0.022 ($z = -0.19$).

[17] The unpublished appendix is available at http://www.bus.vcu.edu/economics/harless. In addition to the results for vehicle lines adopting airbags in model years 1989–1995, Table A3 also contains results for an equation that does not assume fixed effects for vehicle lines and results for a subsample of that excludes any vehicle line that had a change in physical characteristics (see footnote 14). Results are very similar to those contained in Table 4. It is of interest that a Hausman specification test does not suggest there is a significant difference in the coefficients between the conditional logit (Table 4) and logit (Table A3) estimates.

increase was also presented as potentially attributable to offsetting behavior (Peterson and Hoffer, 1994, 1996; Peterson, Hoffer, and Millner, 1995). Our failure to find an increase in the incidence of grievous acts among drivers of airbag-equipped vehicles makes this attribution suspect. Our results concerning the grievous actions of drivers of rental vehicles (Table 4), however, suggest an alternate explanation for the increase in the personal injury claims index.

An increase in relative personal injury claims after airbag adoption was in evidence for 1990 and 1992, but not 1991 (when few airbag adoptions occurred) or 1993. Driver's side airbags first became widely available when Chrysler added them to its entire automotive line for the 1990 model year. (They were standard on the Lebaron J convertible and the Dodge Daytona in 1989 and on some lower-volume luxury vehicles in earlier years.) Ford, GM, and Toyota added airbags to one or more vehicles in 1990 as well. By 1995, nearly all new automobiles and minivans sold in the United States had driver's side airbags. The early years of airbag adoptions corresponded to the time period when automakers purchased interests in rental car companies such as Hertz (Ford), National (GM), Thrifty (Chrysler), and Value (Mitsubishi). The impetus for this action was the belief that rental fleet sales could stabilize seasonal production variations (ADT Automotive, 2002, p. 38–39). Furthermore, by turning over the rental fleets more quickly, the "almost new" rental cars could be used as an additional price discrimination tool in the new car markets. These structural changes in the new car market coincided with a recession that decreased new car demand substantially. The result was that, as illustrated in Figure 2, the proportion of new cars in rental service increased 2.5-fold between 1987 and 1992.

Conjecturing that the change in the personal injury claims might be due to the changing pattern of vehicle ownership that occurred at the time driver's side airbags were

FIGURE 2
Chart Demonstrating Change in Ownership Pattern Coinciding With the Period of Airbag Adoption. Sources: *Automotive Fleet Fact Book*, 1997 (Redondo Beach, Calif.: Bobit Publishing Co.); *Used Car Market Report*, 1998 (Nashville, Tenn.: ADT Automotive); and *Automotive News Market Data Book*, 1996 (Detroit, Mich.: Crain Communications)

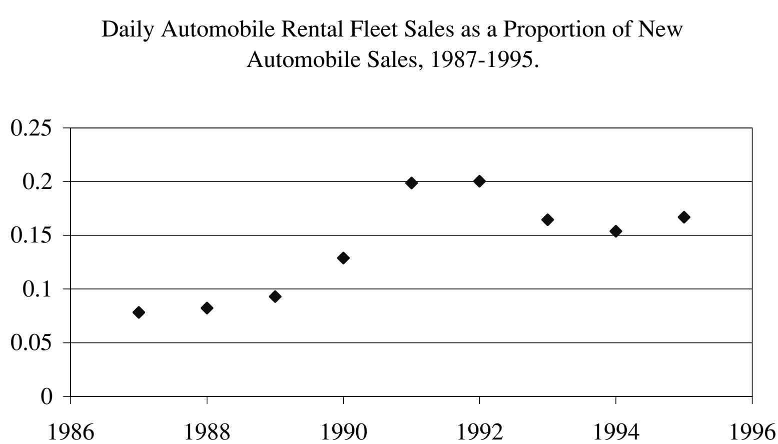

TABLE 5
Analysis of Change in Relative Personal Injury Index for Vehicle Lines That Adopted an Airbag in 1990

	Change in Relative Personal Injury Index From 1989 to		
	1990	1991	1992
Airbag Adopted in 1990	6.788*	4.700	3.001
	(2.724)	(3.087)	(3.949)
Vehicle Larger	1.233	0.767	0.121
	(4.155)	(3.596)	(3.950)
Constant	0.810	0.933	2.342
	(1.118)	(1.364)	(1.981)
Number of observations	81	75	57
R^2	0.075	0.031	0.011
F-statistic	3.17	1.17	0.31
Degrees of Freedom	2,78	2,72	2,54
P-value	0.047	0.32	0.74

*Significant at the 5% level.

adopted, we attempted to obtain additional data distinguishing rental and total registrations from R. L. Polk and Company. Conversations with a representative of the Polk Company, however, revealed that Polk did not separately identify registrations of rental vehicles until 1994 (when their registration databases were changed to reflect the structural changes described above). Hence, despite the (evidently approximate) overall figures suggesting a marked change in the proportion of daily rental vehicle registrations, no information is available on rental registrations for individual vehicle lines during the period (1989–1993) in which relative personal injury claims rose after airbag adoption.

Nevertheless, we can demonstrate how the increase in the index of personal injury claims after airbag adoption moderates as the claims record for a vehicle becomes more reflective of the experience of private owners and less influenced by daily rental service.[18] In Table 5 we repeat the analysis from Peterson, Hoffer, and Millner (1995) for vehicles adopting an airbag in 1990 and then show how their main conclusion changes as the influence of injury claims in rental vehicles becomes smaller. The first column of Table 5 (having the heading 1990) shows, as in Peterson, Hoffer, and Millner,

[18] The Highway Loss Data Institute index of personal injury losses is based on reported private vehicle losses in "no fault" states from the insurer sponsors of the Institute. Unless at the time of rental customers specifically purchase liability insurance coverage from the rental car company, the car rental firm holds the renter's insurance company liable in an accident. Thus, losses from accidents involving rental vehicles where the renter chose not to purchase coverage from the car rental firm are reflected in insurer losses. To the extent that some vehicle renters purchase the liability coverage offered by the car rental firm, the Highway Loss Data Institute data, which reflects losses from private policies only, understates the change in liability losses when a higher proportion of vehicles are placed in rental service.

the Ordinary Least Squares results from regressing the change in the personal injury index from 1989 to 1990 on a dummy variable indicating if the vehicle-line adopted an airbag in 1990 (*Airbag Adopted in 1990*) and a dummy variable indicating whether the vehicle line became larger in 1990 (*Vehicle Larger*). The coefficient for the airbag adoption dummy variable is 6.788 ($t = 2.49$, $P = 0.015$) indicating that vehicles with a new airbag had an increase in personal injury claims of nearly 7 percent.[19]

The personal injury claim index numbers calculated by the Highway Loss Data Institute are cumulative over a 3-year period except when a model has an important change in safety equipment (e.g., an airbag) or when the vehicle is redesigned substantially. Given the way the index of personal injury claims is constructed, the airbag coefficient for 1990 reflects differences between the *cumulative* 1989 index number and the *noncumulative* 1990 index number (the 1989 index number is based on the injury claim experience of 1987 to 1989 model-year vehicles in calendar years 1987 to 1989, whereas for newly airbag-equipped vehicle lines the 1990 index number reflects personal injury claims of 1990 model year vehicles in calendar year 1990 only). Since new daily rental vehicles at that time were in service from 5 to 9 months, the higher injury experience of vehicles in rental service would have the largest impact on the index number in the first year the vehicle has an airbag. The index numbers for the subsequent years would be less sensitive to injury experience in rental service as airbag-equipped rental vehicles are resold as "program cars" to private owners. Hence, we expect that size of the *Airbag Adopted in 1990* coefficient will become smaller as we compare the 1989 index numbers to personal injury index numbers subsequent to 1990.

The results in the second two columns of Table 5 bear out this conjecture. The results in the second column are for the dependent variable difference in personal injury index numbers between 1991 and 1989, and the 1991 index number for vehicles equipped with an airbag reflects injury experience for 1990 and 1991 model year vehicles in calendar years 1990 and 1991. The *Airbag Adopted in 1990* coefficient is now two points lower and no longer statistically significant ($t = 1.52$, $P = 0.13$). The results in the third column are for the dependent variable difference in personal injury index numbers between 1992 and 1989, and the 1992 index number for vehicles equipped with an airbag reflects injury experience for 1990 through 1992 model year vehicles in 1990 to 1992. The *Airbag Adopted in 1990* coefficient is now less than half the size when we used the 1990 injury index number and the coefficient is insignificant ($t = 0.759$, $P = 0.45$).[20] Note that the sample sizes are smaller as we change the period of comparison because we exclude vehicles that adopted airbags in the interim; for example, when we use the 1992 injury index numbers the sample size is 57 because we have excluded vehicles that adopted an airbag in 1991 or 1992. Our conclusions are the same if we were to use, instead, only these 57 vehicles in each of the three regressions.

If offsetting behavior or adverse recruitment were behind the rise in the index of personal injury claims after airbag adoption, then there should be no difference in the

[19] These results differ slightly from Peterson, Hoffer, and Millner as we found and corrected several minor errors. The effect of these corrections was to *increase* the size and statistical significance of the airbag coefficient.

[20] The same phenomenon can be detected for vehicle lines switching to airbags in 1991, 1992, and 1993.

results whether we compared the preairbag injury claim experience to the first year with an airbag or the first several years with an airbag. But the results in Table 5 show that there is such a difference.

We conclude that the method of calculation of the Highway Loss Data Institute personal injury loss index numbers and several concurrent events over the 1988–1993 period can explain the increase in the index injury losses for newly airbag-equipped vehicles: a 2.5-fold increase in the proportion of rental cars in service coincident with the adoption of airbags in automobiles; the turnover of rental fleets in under a year; the greater likelihood of rental car drivers to take actions leading to accidents; and the Highway Loss Data Institute procedure of restarting their (usually) cumulative index numbers for a vehicle line upon adoption of an airbag. Together these factors would influence Highway Loss Data Institute index numbers at the shortest interval after airbag adoption, maximizing the impact of daily rental vehicles on the injury index in the first year after airbag adoption.

CONCLUSION

Our analysis of thousands of fatal accidents involving vehicle lines adopting a driver's side airbag as standard equipment in the 1992–1995 model years provides no evidence supporting the offsetting behavior hypothesis. We find strong evidence of adverse recruitment for drivers with previous DWI convictions. There is slight evidence of advantageous recruitment when we examine counts of driver's license suspensions, but no consistent evidence of adverse or advantageous recruitment when we examine the number of previous speeding tickets or motor vehicle accidents. Controlling for the vehicle line, driver age, sex, and previous record, as well as addressing a selection bias in the FARS data set (Porter and Levitt, 2001), we find there is no change in the probability of drivers committing acts that significantly contribute to the occurrence of the fatal accident after the vehicle line is equipped with an airbag. Hence, we conclude that the result reported in Peterson, Hoffer, and Millner (1995) that airbag-equipped vehicles were more likely to be at fault in 30 multivehicle accidents in Virginia in 1993 is an idiosyncrasy.

Our finding of no offsetting behavior in the case of airbags supports the Lund and O'Neill (1986) conjecture that offsetting behavior is more likely to occur for accident-reducing rather than for injury-reducing measures such as airbag adoption. Stronger support for the offsetting behavior hypothesis occurs when accident-reducing equipment such as studded snow tires (Rumar, 1976) are adopted or when weather (Traynor, 1993; Evans, 1985) or lighting (Assum et al., 1999) affect driving conditions and hence the likelihood of an accident. Evidence of offsetting behavior is weaker (mandatory seatbelt laws) or absent altogether (airbags) for injury-reducing measures.

Though our study overturns some evidence previously taken as supportive of the offsetting behavior hypothesis, our explanation of the change in the insurance industry statistics supports the idea that drivers are subject to moral hazard. We provide evidence to suggest that the rise in an index of personal injury claims after airbag adoption, previously attributed to adoption of airbags, may be due to the influence of vehicles in rental service on the index numbers and to a significant rise in the proportion of new vehicles in rental service during the period of airbag adoption.

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