The behavioral response of drivers to increased highway speed limits*

Adam D. Zubritsky, Shelby Gerking†, Michael Caputo

Department of Economics, College of Business Administration, University of Central Florida, Orlando, FL 32816, United States

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Abstract

Previous studies have focused on offsetting behavior of drivers in response to vehicle safety features. This paper examines the behavioral response of drivers of cars and light trucks to recent increases in highway speed limits.

Keywords: offsetting behavior; speed limits; driver behavior

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† Corresponding author. Telephone: 1.407.823.4729, Fax: 1.407.823.3269, email: sgerking@bus.ucf.edu.

1. Introduction

Formulating efficient highway safety policies depends critically on understanding the way alternative regulations affect the driver behavior as well as how driver behavior affects roadway accidents. Highway speed limits are an important example of these regulations nevertheless disagreement remains concerning their effects. Chirinko and Harper (1993) argue that increases in highway speed limits result in more collisions between vehicles, but have no effect on collisions with pedestrians, who seldom walk beside highways. Lave (1985) on the other hand, concluded that speed limit increases reduce the variance of speeds of vehicles sharing a roadway, causing vehicle collisions to decline.

This paper further analyzes the relationship between increases in highway speed limits, offsetting behavior of drivers (Peltzman, 1975), and pedestrian fatalities. The relationship is divided into a substitution effect and a vehicle miles traveled effect. The substitution effect recognizes that at constant vehicle miles traveled, higher speed limits permit faster driving, thereby decreasing traffic congestion on highways. This provides more aggressive drivers, namely those in light trucks (Gayer, 2004), with an incentive to make more use of highways and less use of streets and roads where pedestrians are present, and therefore results in a decline in vehicle collisions with pedestrians. The vehicle miles effect recognizes that if relative roadway use is held constant, increased highway speed limits result in more miles driven on all types of roads and more possibilities for vehicle collisions with pedestrians. Empirical estimates in Section 3 show that the substitution effect is present for light trucks, but is absent for cars, the vehicle miles effect is positive for both light trucks and cars, and that the vehicle miles effect dominates the substitution effect for both types of vehicles combined as highway speed limits are increased to 75 MPH or higher.

2. Economic model

The model presented below is intended to motivate the econometric setup. A driver maximizes utility $U(x,G,t_D)$, where $x > 0$ is a composite good, $G > 0$ is the amount of protection afforded the occupants of a vehicle if a collision occurs, and $t_D > 0$ is time spent driving. Assume that $\partial U(x,G,t_D)/\partial x > 0$, $\partial U(x,G,t_D)/\partial G > 0$, and $\partial U(x,G,t_D)/\partial t_D < 0$. The amount of *x* that an individual consumes depends on miles driven, thus $x = X(M)$, where $M > 0$ is the number of miles driven and $X'(M) > 0$ (by driving more miles, a greater range of goods can be consumed). Driving time is a function of vehicle protection $G > 0$, miles driven $M > 0$, exogenously determined roadway constraints Ω (e.g., speed limits), and a vector of demographic characteristics θ, such as age and gender, that may affect propensity to take risks:

$$t_D = T_D(G,M;\Omega,\theta). \tag{1}$$

A vehicle offering more protection motivates faster driving. Thus, at an unchanged number of miles driven, less time will be spent driving, i.e., $\partial T_D(G,M;\Omega,\theta)/\partial G \le 0$, thereby making more time available for work (t_W). Moreover, for a given vehicle, more miles traveled at a set average speed results in more time driving, hence $\partial T_D(G,M;\Omega,\theta)/\partial M \ge 0$.

Utility is maximized subject to money and time constraints specifying that all income is spent on *M* and *G* (the explicit cost of *x* is ignored) and total time is divided between driving and work. Combining these constraints yields $P_M M + P_G G + wT_D(G,M;\Omega,\theta) = wT$, where $P_M > 0$ is the cost per mile driven, $P_G > 0$ is the price per unit of *G*, $w > 0$ is the wage and $T > 0$ is total time available. The model can be solved for the utility maximizing values of the choice variables (G,M) in terms of the parameters, yielding for example

$$M = M^*(P_G,P_M,w,\Omega,\theta,T). \tag{2}$$

3. Empirical analysis

Equations (1) and (2) are estimated using data from Gayer's (2004) study of driver offsetting behavior. These data merge information on pedestrian fatalities by state and road type (urban and rural) for the period 1994–1998 from the Fatality Analysis Reporting System, with information on vehicle miles traveled by vehicle type (car or light truck), state, year, and road type obtained from the Federal Highway Administration Highway Statistics Series. Observations are available over both road types across 46 states during the 5-year period. Because some data were missing, 394 observations were used in the regressions for each vehicle type. During this period, 30 states increased speed limits on their urban or rural roads either from 55 MPH to 65 MPH, to 70 MPH, or to 75 MPH or higher. In Equation (1), the number of pedestrians who die within 30 days after being struck by a motor vehicle is used to proxy attempts to save driving time (t_D), G is controlled by separately analyzing pedestrian deaths from collisions with cars and pedestrian deaths from collisions with light trucks, and Ω and θ are measured using dummy variables for speed limit changes and proportions of a state's population in various age/gender categories. Equation (2) is estimated using state per-gallon gasoline tax rates as a measure of P_M and gross state product per capita as a measure of w. State population is added to the regression because, when estimated, Equation (2) is aggregated from the individual level to the state level. The same measures of Ω and θ are included as explanatory variables as well.

Equations (1) and (2) form a triangular system and are estimated by 3SLS for both cars and light trucks (see Green, 2003, pp. 407-409 and Prucha 1987). All equations are estimated in linear form and include state and year fixed effects. In the model for cars, the errors in the two equations have a correlation coefficient of 0.95, and for light trucks the corresponding error correlation is 0.15. Both correlation coefficients test different from zero at the 5% level using Fisher transformed values (Sheskin 2000, pp. 778-779).

Coefficient estimates are presented in Tables 1 and 2. Table 1 shows that speed limit increases generally are associated with an increase in vehicle miles traveled for both cars and light trucks. Both vehicle types travel more miles on urban roads than on rural roads. Increases in state population increase vehicle miles traveled for light trucks, but not cars. Coefficients of the age, gender, gasoline tax, and per capita income variables are not significant at the 5% level.

Table 2 presents estimates of equations for pedestrian fatalities. In the equation for light trucks (Column (2)), the coefficient of vehicle miles traveled is positive and significantly different from zero at the 5% level, whereas in the equation for cars (Column (1)), the corresponding coefficient is not significantly different from zero at 5%, suggesting offsetting behavior by light truck drivers. Additionally, increases in speed limits are associated with reductions in pedestrian deaths for light trucks, but not for cars, when vehicle miles traveled is held constant (the substitution effect). Coefficients of other controls do not differ significantly from zero at 5%.

Reduced form equations for pedestrian deaths estimated by OLS are shown in Columns (3) and (4) of Table 2. Heteroskedasticity-robust standard errors are presented (White, 1980). These equations show the total effects of speed limit changes on deaths, allowing for changes in vehicle miles traveled. Total effects on speed limit and road type controls calculated directly from the three-stage least squares estimates are similar to those obtained under OLS. For cars, increases in highway speed limits to 75 MPH or higher result in a significant increase in pedestrian deaths, while increases in highway speed limits to 65 MPH or 70 MPH do not. For light trucks, increases in the state speed limit to 65 MPH, 70 MPH, or 75 MPH or over have no effect on pedestrian fatalities. These estimates suggest that speed limit increases decrease the relative proportion of pedestrian deaths caused by light trucks as compared with cars.

Column (5) of Table 2 shows results from estimating the reduced form fatalities equations for cars and light trucks combined. The outcome provides evidence that increasing the speed limit from 55 MPH to either 65 MPH or to 70 MPH does not significantly affect the number of pedestrian deaths, but increasing the limit to 75 MPH or above results in significantly more pedestrian deaths caused by both types of vehicles. Thus, at the highest speed limits, the vehicle miles effect dominates the substitution effect for both types of vehicles combined. This conclusion turns out to be stronger when re-estimating the two models after dividing vehicle miles traveled and pedestrian fatalities by state population (results available from the authors on request).

4. Conclusion

This paper presented a model with supporting empirical evidence suggesting that increases in highway speed limits during the mid-1990s may have been responsible for a shift in the distribution of pedestrian fatalities caused by light trucks and cars. Holding vehicle miles traveled constant, increased highway speed limits encourage the fastest and most aggressive drivers (those in light trucks) to substitute in favor of using highways where they are less likely to collide with pedestrians. Increased highway speed limits also encourage people to drive more miles because more ground now can be covered per unit of time. At the highest highway speed limits observed in the U.S. (75 MPH and up), this vehicle miles traveled effect appears to dominate the substitution effect, leading to an overall increase in pedestrian fatalities caused by both types of vehicles.

References

Chirinko, R.S., Harper, E.P., 1993. Buckle up or Slow Down? New Estimates of Offsetting Behavior and their Implications for Automobile Safety Regulation. Journal of Policy Analysis and Management 12, 270 – 296.

Gayer, T., 2004. The Fatality Risks of Sport-Utility Vehicles, Vans, and Pickups Relative to Cars. Journal of Risk and Uncertainty 28, 103 – 133.

Greene, W.H., 2003. Econometric Analysis, 5th edn. Prentice Hall, Upper Saddle River, NJ.

Lave, C.A., 1985. Speeding, Coordination, and the 55 MPH Limit. American Economic Review 75, 1159 – 1164.

Peltzman, S., 1975. The Effects of Automobile Safety Regulation. Journal of Political Economy 83, 677 – 725.

Prucha, I., 1987. The Variance-Covariance Matrix of the Maximum Likelihood Estimator in Triangular Structural Systems: Consistent Estimation. Econometrica 55, 977 – 978.

Sheskin, D.J., 2000. Handbook of Parametric and Non-Parametric Statistical Procedures, 2nd edn. Chapman and Hall/CRC, Boca Raton, FL.

White, H., 1980. A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. Econometrica 48, 817 – 838.

Table 1
Vehicle miles traveled in cars and light trucks

	Mean (Standard deviation) (1)	3SLS triangular Cars (2)	3SLS triangular Light trucks (3)
Control = 1 if state speed limit is set at 55 MPH, = 0 otherwise	---[a]	---[a]	---[a]
Control = 1 if state speed limit is set at 65 MPH, = 0 otherwise	0.355 (0.479)	51.906* (20.560)	7.961* (3.090)
Control = 1 if state speed limit is set at 70 MPH, = 0 otherwise	0.084 (0.277)	-16.242 (30.179)	-2.723 (4.535)
Control = 1 if state speed limit is set at 75 MPH or over, = 0 otherwise	0.066 (0.249)	108.964* (31.885)	17.071* (4.794)
Control = 1 if pedestrian fatality occurred on urban road, = 0 otherwise	0.495 (0.501)	129.243* (19.298)	20.278* (2.900)
Control = 1 if pedestrian fatality occurred on rural road, = 0 otherwise	---[a]	---[a]	---[a]
Percentage of each state's population that is comprised of men age 65 and over	5.291 (0.855)	-40.626 (261.658)	-9.151 (39.599)
Percentage of each state's population that is comprised of women age 65 and over	7.513 (1.314)	-39.243 (194.345)	-10.973 (29.579)
Percentage of each state's population that is comprised of men age 25 and under	10.649 (0.718)	-33.099 (182.717)	-5.917 (28.137)
Percentage of each state's population that is comprised of women age 25 and under	10.432 (0.740)	15.182 (177.019)	4.317 (27.197)
Amount of state tax paid on retail gasoline expressed in cents per gallon	19.473 (5.304)	1.581 (1.810)	-0.218 (0.851)
Total population of each state expressed in hundred thousands	50.661 (55.038)	6.243 (4.514)	1.636* (0.713)
Per-capita income in each state expressed in thousands of U.S. dollars	29.394 (6.612)	-0.662 (0.573)	0.006 (0.024)
R-squared		0.7324	0.7863

[a] Omitted dummy variable.
* Denotes significance at the 5% level of a two-sided test.

Table 2
Pedestrian fatalities caused by cars and light trucks

	3SLS triangular		Reduced-form OLS		
	Cars	Lt. trucks	Cars	Lt. trucks	Combined
	(1)	(2)	(3)	(4)	(5)
Vehicle miles traveled in each vehicle type in each state expressed in hundred millions	-0.074 (0.213)	0.745* (0.207)			
Control = 1 if state speed limit is set at 55 MPH, = 0 otherwise	---[a]	---[a]	---[a]	---[a]	---[a]
Control = 1 if state speed limit is set at 65 MPH, = 0 otherwise	8.457 (12.970)	-5.254* (2.264)	4.651 (3.877)	0.658 (1.974)	5.310 (5.694)
Control = 1 if state speed limit is set at 70 MPH, = 0 otherwise	-13.541 (9.485)	-8.673* (2.212)	-12.321 (9.553)	-10.747 (5.500)	-23.067 (14.869)
Control = 1 if state speed limit is set at 75 MPH or over, = 0 otherwise	22.177 (25.736)	-9.010* (4.338)	14.072* (4.469)	3.729 (2.563)	17.801* (6.813)
Control = 1 if pedestrian fatality occurred on urban road, = 0 otherwise	33.609 (28.675)	-5.450 (4.519)	24.043* (3.307)	9.642* (1.672)	33.685* (4.806)
Control = 1 if pedestrian fatality occurred on rural road, = 0 otherwise	---[a]	---[a]	---[a]	---[a]	---[a]
Percentage of each state's population that is comprised of men age 65 and over	-10.897 (81.183)	-3.102 (19.198)	-7.680 (42.358)	-11.043 (21.886)	-18.723 (63.395)
Percentage of each state's population that is comprised of women age 65 and over	-14.090 (63.337)	9.859 (15.371)	-8.763 (31.068)	1.536 (16.152)	-7.227 (46.467)
Percentage of each state's population that is comprised of men age 25 and under	-12.165 (58.458)	13.152 (13.915)	-6.958 (23.290)	8.495 (11.412)	1.537 (33.865)
Percentage of each state's population that is comprised of women age 25 and under	12.608 (56.022)	-12.242 (13.362)	10.052 (24.116)	-9.366 (12.078)	0.686 (35.418)
Amount of state tax paid on retail gasoline expressed in cents per gallon			-0.528 (0.557)	-0.072 (0.293)	-0.600 (0.830)
Total population of each state expressed in hundred thousands			-0.363 (3.509)	1.185 (1.663)	0.821 (5.123)
Per-capita income in each state expressed in thousands of U.S. dollars			0.182 (1.319)	-0.077 (0.789)	0.106 (2.090)
R-squared	0.4016	0.8857	0.6358	0.6782	0.6538