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D. Mark Anderson
Yang Liang
Joseph J. Sabia

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ABSTRACT

Using data from the Fatality Analysis Reporting System for the period 1983-1997, Cohen and Einav (Review of Economics and Statistics 2003; 85(4): 828–843) found that mandatory seatbelt laws were associated with a 4 to 6 percent reduction in traffic fatalities among motor vehicle occupants. After successfully replicating their two-way fixed effects estimates, we (1) add 22 years of data (1998-2019) to capture additional seatbelt policy variation and observe a longer post-treatment period, (2) employ the interaction-weighted estimator proposed by Sun and Abraham (2021) to address potential bias due to heterogeneous and dynamic treatment effects, and (3) estimate event-study models to investigate pre-treatment trends and explore lagged post-treatment effects. Consistent with Cohen and Einav (2003), our updated estimates show that primary seatbelt laws are associated with a 5 to 9 percent reduction in fatalities among motor vehicle occupants. Estimated effects of secondary seatbelt laws are smaller in magnitude and sensitive to model choice.

D. Mark Anderson
Department of Agricultural Economics
& Economics
Montana State University
P.O. Box 172920
Bozeman, MT 59717
and NBER
dwight.anderson@montana.edu

Yang Liang
San Diego State University
Department of Economics
Center for Health Economics
& Policy Studies
5500 Campanile Drive
San Diego, CA 92182
yang.liang@sdsu.edu

Joseph J. Sabia
San Diego State University
Department of Economics
Center for Health Economics
& Policy Studies
5500 Campanile Drive
San Diego, CA 92182
and IZA & ESSPRI
jsabia@sdsu.edu

1. INTRODUCTION

In 2020, traffic fatalities were the second leading cause of unintentional injury deaths among 1- through 44-year-olds in the United States (Centers for Disease Control and Prevention 2022). Over the past 40 years, mandatory seatbelt laws have become one of the most prominent demand-side policies designed to curb traffic fatalities. These laws, which impose civil fines on violators, take two forms: primary seatbelt laws (PSLs) and secondary seatbelt laws (SSLs). PSLs allow law enforcement officials to stop and cite violators independent of any other traffic behavior. SSLs permit citations for not wearing a seatbelt only if drivers have been stopped for a separate traffic offense. Recently, the National Governors Association listed the implementation of primary seatbelt laws as their top strategy to improve driver and passenger safety (Dedon et al. 2018). As of January 2022, 34 states and the District of Columbia had a PSL, while 15 states had an SSL.[1]

An early literature explored the relationship between mandatory seatbelt laws and traffic fatalities, but these studies were limited by time-series identification (Battacharrya and Layton 1979; Harvey and Durbin 1986; Wagenaar et al. 1988; Houston et al. 1995) or focused on only one policy change (Battacharyya and Layton 1979; Garbacz 1991; Houston and Richardson 2002). Using a more credible research design, subsequent papers relied on two-way fixed effects (TWFE) models, controlling for common shocks and time-invariant differences across states (Cohen and Einav 2003; Morrisey and Grabowski 2005; Houston and Richardson 2006; Carpenter and Stehr 2008).

Of the studies listed above, Cohen and Einav (2003) stands out as the seminal and most well-cited publication.[2] Using data from the Fatality Analysis Reporting System (FARS) for the period 1983-1997, Cohen and Einav (2003) found that PSLs and SSLs were associated with 5.9 and

[1] New Hampshire is the only state without a primary or secondary seatbelt law (Voornas 2021).

[2] According to Google Scholar, Cohen and Einav (2003) has been cited over 400 times. To put this into perspective, the well-known traffic safety pieces by Levitt and Porter (2001) and Levitt (2008), and their replications (Dunn and Tefft 2020; Jones and Ziebarth 2016), have been cited a combined 321 times.

4.0 percent reductions, respectively, in the fatality rate among motor vehicle occupants.[3] Further, they found little evidence to suggest that mandatory seatbelt laws induced a Peltzman effect (i.e., riskier driving behavior), as proxied by the non-occupant traffic fatality rate.[4]

In this study, we successfully replicate Cohen and Einav's (2003) TWFE estimates of the relationship between mandatory seatbelt laws and traffic fatalities. We then extend Cohen and Einav's (2003) analysis in three ways. First, we add 22 years of data, increasing the sample time frame from 1983-1997 to 1983-2019. During the period 1998-2019, 21 states upgraded their laws from SSLs to PSLs.[5] Second, if the effects of mandatory seatbelt laws were dynamic and heterogeneous, then TWFE estimates may be biased (Goodman-Bacon 2021). To address this potential issue, we report results from Sun and Abraham's (2021) interaction-weighted estimator. Finally, we estimate event-study models to investigate pre-treatment trends and explore lagged post-treatment effects. Consistent with the results reported in Cohen and Einav (2003), our estimates suggest that PSLs are associated with a 5 to 9 percent reduction in fatalities among motor vehicle occupants. SSLs, on the other hand, are associated with markedly weaker effects.

2. REPLICATION AND EXTENSION OF COHEN AND EINAV (2003)

To replicate Cohen and Einav's (2003, Table 5) reduced-form estimates of the relationship between mandatory seatbelt laws and traffic fatalities, we estimate the following TWFE regression:

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[3] Using data from the FARS for the period 1985-2000, Morrisey and Grabowski (2005) found that both PSLs and SSLs were effective at reducing traffic fatalities among individuals aged 65 and older. Using FARS data for the period 1990-2002, Houston and Richardson (2006) found that upgrading from an SSL to a PSL led to large reductions in fatality rates among motor vehicle occupants. Lastly, using FARS data for the period 1991-2005, Carpenter and Stehr (2008) found that both types of seatbelt laws reduced teenage traffic fatalities.

[4] The Peltzman effect suggests that mandatory seatbelt use may encourage risk-compensating behaviors, such as driving faster, taking dangerous alternative routes, or driving under more hazardous weather conditions (Peltzman 1975).

[5] Expanding the sample period also increases the average number of post-treatment years of data available for PSLs (which were not preceded by an SSL) from 10.6 to 32.6 and for SSLs from 8.2 to 30.2.

$$Occupant\ fatalities_{st} = \beta_0 + \beta_1 SSL_{st} + \beta_2 PSL_{st} + \beta_3 SSL\ to\ PSL_{st} + \boldsymbol{X}_{st}'\boldsymbol{\beta_4} + a_s + \tau_t + \varepsilon_{st} \qquad (1)$$

where $Occupant\ fatalities_{st}$ is the occupant traffic fatality rate per vehicle miles traveled (VMT) in state s during year t.[6] The variable SSL_{st} is set equal to 1 the year in which a state adopted an SSL and remains equal to 1 in all following years (even if that state subsequently upgrades to a PSL). The variable PSL_{st} is set equal to 1 the year in which a state adopted a PSL (which was not preceded by an SSL) and remains equal to 1 thereafter, while $SSL\ to\ PSL_{st}$ is set equal to 1 the year in which a state adopted a PSL (which was preceded by an SSL) and remains equal to 1 thereafter.[7] The vector $\boldsymbol{X}_{st}$ contains the same set of time-varying state-level controls used by Cohen and Einav (2003). State fixed effects are represented by the vector a_s and year fixed effects are represented by τ_t. Appendix Table 2 provides descriptive statistics, definitions, and sources for the variables used in our analysis.[8]

Columns (1) and (2) of Table 1 show the estimates reported in Table 5 of Cohen and Einav (2003) for occupant and non-occupant traffic fatalities, respectively. Column (3) shows our successful replication of their estimates for the occupant fatality rate, while correcting our standard errors for clustering at the state level (Bertrand et al. 2004).[9] Specifically, we find that the adoption of a PSL (not preceded by an SSL) is associated with a 0.0012 decline in the occupant fatality rate, which represents a 5.43 percent decrease relative to the pre-treatment mean of 0.0221. We also find

[6] Cohen and Einav (2003) also estimated the relationship between seatbelt usage rates and traffic fatalities, using mandatory seatbelt laws as instrumental variables. While not the primary focus of our study, we replicate and extend these estimates at the end of this section.

[7] Appendix Table 1 lists when SSLs and PSLs went into effect. Over the period 1983-1997, 42 states enacted an SSL, 8 states enacted a PSL that was not preceded by an SSL, and 6 states enacted a PSL that was preceded by an SSL.

[8] Following Cohen and Einav (2003), we take the natural log of the continuous controls included on the right-hand side of the estimating equation.

[9] Cohen and Einav (2003) reported robust standard errors.

that SSLs are associated with a 0.0007 decline in the occupant fatality rate, or a 3.30 percent decrease relative to the pre-treatment mean. Importantly, these estimates are nearly identical to those reported in Cohen and Einav (2003). Similar to the original authors, we also find that the relationship between PSLs that were preceded by an SSL and occupant traffic fatalities is small and nowhere near statistically significant.

Peltzman's (1975) theory of risk-compensating behavior posits that seatbelt-wearing drivers will drive less carefully because they feel safer. This leads to the prediction that seat belt usage and fatalities among non-occupants (i.e., pedestrians, bicyclists, and other unclassified non-occupants) will be positively correlated. In column (4), and consistent with Cohen and Einav (2003), we find little evidence to support this hypothesis. Across all seatbelt law indicators (*SSL*, *PSL*, and *SSL to PSL*), the coefficient estimates are small and statistically indistinguishable from zero.

2.1. Extending the sample period from 1983-1997 to 1983-2019

In columns (5) and (6) of Table 1, we add 22 years of data and extend the sample period through 2019. During the period 1998-2019, 21 states upgraded their mandatory seatbelt laws from secondary to primary. Despite substantially lengthening the sample period, the coefficient estimates on the *SSL*, *PSL*, and *SSL to PSL* indicators for both occupant and non-occupant fatalities are similar to those reported in columns (1)-(4). Specifically, we find that the adoption of a PSL (not preceded by an SSL) is associated with a 0.0020 decline in the occupant fatality rate, or a 9.05 percent decrease relative to the pre-treatment mean. SSLs are associated with a 3.78 percent reduction, and the coefficient estimate on *SSL to PSL* remains small and statistically insignificant. Again, we find across-the-board null findings when focusing on the non-occupant fatality rate.[10]

[10] In columns (1)-(6) of Appendix Table 3, we re-estimate the TWFE models from columns (1)-(6) of Table 1 but take the natural log of the dependent variable. For the occupant fatality rate, taking the natural log does not change the basic pattern of results. For non-occupants, PSLs are associated with an increase in the fatality rate for the period 1983-1997,

2.2. Interaction-weighted estimates (Sun and Abraham 2021)

In the presence of heterogeneous and dynamic effects of mandatory seatbelt laws, the estimates presented in columns (1)-(6) may be biased (Sun and Abraham 2021). In the final two columns of Table 1, we employ the interaction-weighted estimator developed by Sun and Abraham (2021), who showed that estimates from TWFE models can be biased even when parallel-trends and no-anticipation assumptions hold. In column (7), we use never-treated states (of the particular law in question) as the comparison group and find that the coefficient estimate on the *PSL* indicator is similar to those shown in columns (1), (3), and (5). On the other hand, the estimated effect of SSLs on the occupant fatality rate becomes small in magnitude and is no longer statistically distinguishable from zero. Finally, we find no evidence of a relationship between the *SSL to PSL* indicator and the occupant fatality rate, nor do we find evidence that any of the mandatory seatbelt law indicators are related to the non-occupant fatality rate (column (8)).[11]

In columns (1)-(3) of Appendix Table 5, we experimented with shortening the sample period, allowing us to compare treated states to states that had not adopted *any* mandatory seatbelt law. These estimates are similar to those shown in Table 1. We also explored using the estimator proposed by Callaway and Sant'Anna (2021), of which the Sun and Abraham (2021) estimator is a

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but this estimate becomes statistically insignificant when the panel is extended through 2019. Because Cohen and Einav (2003) reported results from unweighted regressions, we also explored the sensitivity of their TWFE estimates to weighting by state population (columns (1)-(6), Appendix Table 4). For motor vehicle occupants, weighted estimates are similar to the unweighted estimates shown in Table 1. For non-occupants, there is evidence of a positive and statistically significant association between the *SSL to PSL* indicator and the fatality rate in three of the four specifications, consistent with risk-compensating behavior among drivers.

[11] To obtain the interaction-weighted estimates, we ran a separate regression for each mandatory seatbelt law indicator, defining the counterfactual as states never treated by the specific law in question. For instance, to estimate the effect of SSLs on occupant traffic fatalities, we defined the control group as states that never passed an SSL during the sample period. In columns (7) and (8) of Appendix Table 3, we re-estimate the interaction-weighted models but take the natural log of the dependent variable. For motor vehicle occupants, the *PSL* indicator is associated with an approximate 6 percent decrease in the fatality rate, an estimated effect that is similar to those from the TWFE models. For non-occupants, we find that SSLs are associated with a statistically significant increase in the fatality rate, but note that this is the only specification for which we find such a result. Lastly, interaction-weighted estimates that are weighted by state population are presented in columns (7) and (8) of Appendix Table 4.

special case. An advantage of the Callaway and Sant'Anna (2021) procedure is that it considers both not-yet- and never-treated states as counterfactuals. Estimates based on this approach are shown in columns (4) and (5) of Appendix Table 5 and are, again, similar to those presented in Table 1.

2.3. Alternative coding of mandatory seatbelt laws and event-study analyses

Next, in Table 2, we adopt the more parsimonious coding of mandatory seatbelt laws used by Carpenter and Stehr (2008), where the PSL indicator is simply set equal to 1 if state s was enforcing a primary seatbelt law during year t, and equal to 0 otherwise. The SSL indicator is defined analogously, implying that it turns off when the law is upgraded to a PSL. Our results continue to show that PSLs are associated with significant reductions in occupant traffic fatalities, and that SSLs are associated with notably weaker effects. Moreover, these estimates are not sensitive to model choice (i.e., TWFE versus interaction-weighted).

Using this alternative coding, we further modify equation (1) to estimate event-study models. Specifically, we replace the PSL variable with an indicator that is equal to 1 the year in which a PSL goes into effect, 3 leads of this indicator, and 4 lags. The omitted category is defined as the year immediately prior to treatment.[12] Panel A of Figure 1 shows TWFE event-study estimates for occupant fatalities, while panel B shows estimates for non-occupant fatalities. In both panels, the pre-treatment estimated effects are impressively flat, consistent with the notion that the parallel-trends assumption holds. For occupants, there is a striking discontinuous drop in the fatality rate at time $t = 0$, and this effect persists through the remainder of the post-treatment period. During the year in which a PSL goes into effect, there are 0.0009 fewer occupant fatalities per vehicle miles

[12] The event-year dummy at the left-hand endpoint of the event study is set equal to 1 if t is 4 or more years prior to treatment. Likewise, the event-year dummy at the right-hand endpoint is set equal to 1 if t is 4 or more years after treatment.

traveled, which represents a 5.14 percent reduction relative to the pre-treatment mean; after 4 or more years, PSLs are associated with 0.0015 fewer occupant fatalities per vehicle mile traveled (≈ 8.57 percent reduction). The post-treatment estimates of PSLs for non-occupant fatalities, while uniformly negative, are small in magnitude and statistically insignificant.

In Figure 2, we present estimates from interaction-weighted event-study models (Sun and Abraham 2021). An implication of the Sun and Abraham (2021) analysis is that estimates from TWFE event-study models can be contaminated by treatment effects from other periods. For occupant fatalities (panel A), the estimated post-treatment effects increase gradually in magnitude over time. During the year in which a PSL goes into effect, these laws are associated with a (statistically insignificant) 4.47 percent reduction in the occupant fatality rate; after 4 or more years, PSLs are associated with a 8.07 percent reduction, and this estimate is statistically significant at the 0.01 level. Again, there is no evidence of a relationship between PSLs and non-occupant fatalities.[13]

2.4. Seatbelt usage and traffic fatalities

While not a primary focus of this paper, we also replicate and extend Cohen and Einav's (2003) instrumental variables (IV) estimates on the relationship between seatbelt usage and traffic fatalities, where the mandatory seatbelt laws (*SSL*, *PSL*, and *SSL to PSL*) are used to predict seatbelt usage in the first stage (Appendix Table 6).[14] In general, our estimates are similar to those reported by Cohen and Einav (2003), and this holds across level-level (column (1) versus column (3)) and log-

[13] Appendix Figures 1 and 2 show estimates from TWFE and interaction-weighted event-study models, respectively, for SSLs. While there is some evidence of a reduction in the occupant traffic fatality rate during the post-treatment period, the estimated effects are noticeably weaker when compared to those for PSLs.

[14] Following Cohen and Einav (2003), we obtained information on state-level seatbelt usage rates from the Highway Safety Office of each state and from the National Highway Traffic Safety Administration (NHTSA). The NHTSA data include information on state-level usage rates for the period 1991 to 2019.

log specifications (column (2) versus column (4)). Furthermore, our estimates change little when we extend the sample period through 2019.

3. Conclusion

In this paper, we successfully replicate the results reported in Cohen and Einav (2003). Using FARS data for the period 1983-1997, these authors found that PSLs were associated with a 5.9 percent reduction in the occupant fatality rate, while SSLs were associated with a 4 percent reduction. We expand on Cohen and Einav (2003) by (1) adding 22 years of data to their original analysis, (2) using the newly-developed interaction-weighted estimator by Sun and Abraham (2021), and (3) estimating event-study models to investigate parallel pre-treatment trends and explore dynamic post-treatment effects.

Our extension of Cohen and Einav (2003) reveals two important things. First, the estimated effect of PSLs on occupant traffic fatalities is remarkably robust. Adding 22 years of data and employing the interaction-weighted estimator does not materially change Cohen and Einav's (2003) original result. Second, the estimated effect of SSLs is sensitive to model choice and specification. This latter result is particularly important given that much of the previous literature has concluded that SSLs represent an effective tool for reducing traffic fatalities among motor vehicle occupants (see, e.g., Morrisey and Grabowski 2005; Houston and Richardson 2007; Carpenter and Stehr 2008).

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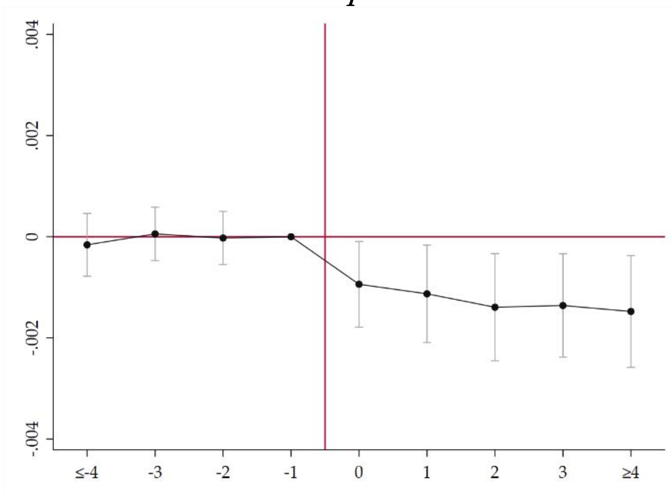
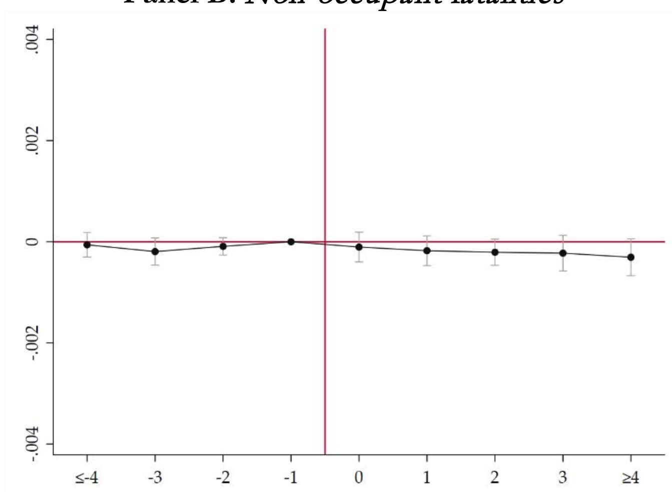
Figure 1. Primary Seatbelt Laws and Traffic Fatalities, 1983-2019: TWFE Event-Study Estimates

Panel A. *Occupant fatalities*



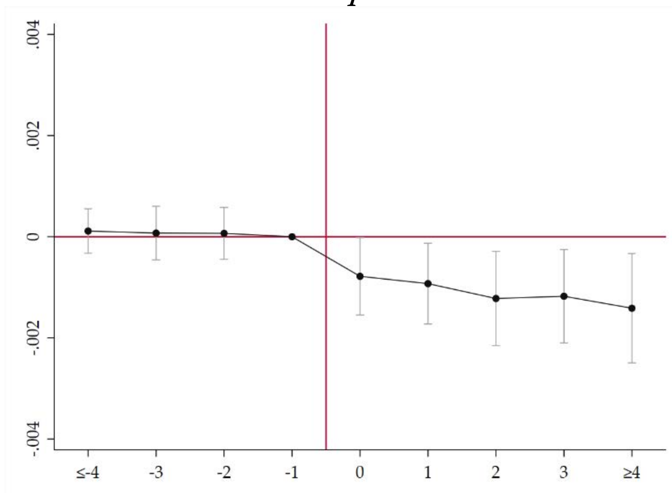
Panel B. *Non-occupant fatalities*



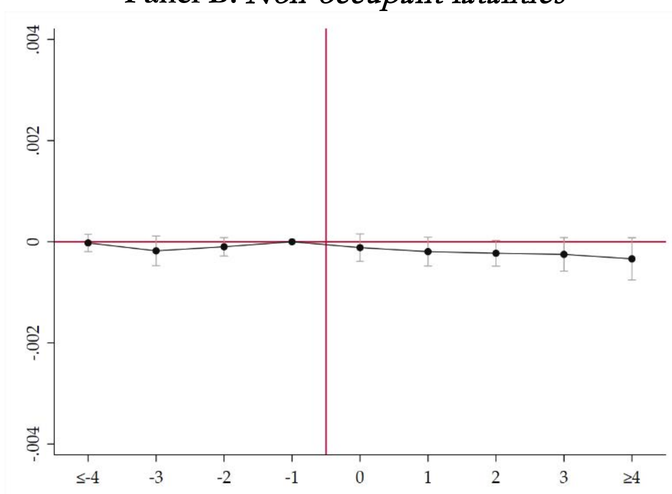
Notes: Based on annual data from the Fatality Analysis Reporting System. Two-way fixed effects estimates (and their 95% confidence intervals) are reported, where the omitted category is one year before treatment. The dependent variable is equal to the number of specified fatalities (occupant or non-occupant) per vehicle miles traveled in state *s* during year *t*. All models control for state fixed effects, year fixed effects, and the state-level characteristics listed in Appendix Table 2. Standard errors are corrected for clustering at the state level.

Figure 2. Primary Seatbelt Laws and Traffic Fatalities, 1983-2019: Interaction-Weighted Event-Study Estimates

Panel A. *Occupant fatalities*



Panel B. *Non-occupant fatalities*



Notes: Based on annual data from the Fatality Analysis Reporting System. Interaction-weighted estimates (and their 95% confidence intervals) are reported, where the omitted category is one year before treatment. The dependent variable is equal to the number of specified fatalities (occupant or non-occupant) per vehicle miles traveled in state *s* during year *t*. All models control for state fixed effects, year fixed effects, and the state-level characteristics listed in Appendix Table 2. Standard errors are corrected for clustering at the state level.

Table 1. Seatbelt Laws and Traffic Fatalities: Replication and Extension of Cohen and Einav (2003)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	TWFE estimates reported in Table 5 of Cohen and Einav (2003)		Replication of Cohen and Einav (2003) + SEs clustered at the state level		Columns (3) and (4) + extending sample period through 2019		Columns (5) and (6) + interaction-weighted estimator from Sun and Abraham (2021)	
	Occupant fatalities	*Non-occupant fatalities*	*Occupant fatalities*	*Non-occupant fatalities*	*Occupant fatalities*	*Non-occupant fatalities*	*Occupant fatalities*	*Non-occupant fatalities*
SSL	-0.0007***	0.0001	-0.0007*	0.0001	-0.0008*	0.00001	-0.0003	0.0002
	(0.0002)	(0.0001)	(0.0004)	(0.0001)	(0.0004)	(0.0001)	(0.0004)	(0.0001)
PSL	-0.0012***	-0.0001	-0.0012**	-0.0001	-0.0020**	-0.0002	-0.0016**	-0.0003
	(0.0005)	(0.0002)	(0.0006)	(0.0002)	(0.0007)	(0.0004)	(0.0008)	(0.0004)
SSL to PSL	-0.0002	0.0003	-0.0001	0.0003	-0.0002	-0.0001	0.0004	0.0006
	(0.0004)	(0.0002)	(0.0005)	(0.0002)	(0.0002)	(0.0001)	(0.0007)	(0.0004)
Pre-*SSL* mean	Not reported	Not reported	0.0212	0.0035	0.0212	0.0035	0.0212	0.0035
Pre-*PSL* mean	Not reported	Not reported	0.0221	0.0046	0.0221	0.0046	0.0221	0.0046
Pre-*SSL to PSL* mean	Not reported	Not reported	0.0186	0.0033	0.0173	0.0028	0.0173	0.0028
Years	1983-1997	1983-1997	1983-1997	1983-1997	1983-2019	1983-2019	1983-2019	1983-2019
N	765	765	765	765	1,887	1,887	1,887	1,887

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from the Fatality Analysis Reporting System. Two-way fixed effects (columns (1)-(6)) and interaction-weighted (columns (7)-(8)) estimates are reported. The dependent variable is equal to the number of specified fatalities (occupant or non-occupant) per vehicle miles traveled in state *s* during year *t*. All models control for state fixed effects, year fixed effects, and the state-level characteristics listed in Appendix Table 2. Standard errors are corrected for clustering at the state level. To obtain the interaction-weighted estimates, we ran a separate regression for each mandatory seatbelt law indicator, defining the counterfactual as states never treated by the specific law in question.

Table 2. Seatbelt Laws and Traffic Fatalities:
Sensitivity of Estimates to Alternative Coding of Seatbelt Laws, 1983-2019

	(1)	(2)	(3)	(4)
	TWFE estimates		Interaction-weighted estimates	
	Occupant fatalities	*Non-occupant fatalities*	*Occupant fatalities*	*Non-occupant fatalities*
SSL	-0.0008*	-0.00005	-0.0007*	0.00004
	(0.0004)	(0.0001)	(0.0004)	(0.0001)
PSL	-0.0012**	-0.0002	-0.0013**	-0.0002
	(0.0004)	(0.0001)	(0.0004)	(0.0002)
Pre-*SSL* mean	0.0211	0.0034	0.0211	0.0034
Pre-*PSL* mean	0.0175	0.0029	0.0175	0.0029
N	1,887	1,887	1,887	1,887

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

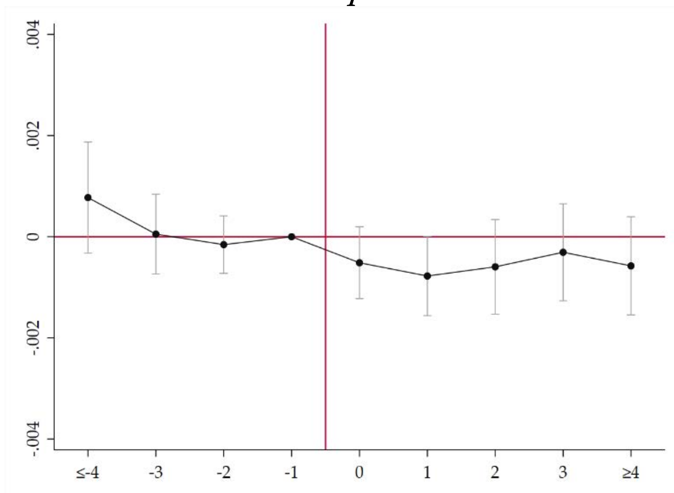
Notes: Based on annual data from the Fatality Analysis Reporting System. Two-way fixed effects (columns (1)-(2)) and interaction-weighted (columns (3)-(4)) estimates are reported. The dependent variable is equal to the number of specified fatalities (occupant or non-occupant) per vehicle miles traveled in state *s* during year *t*. All models control for state fixed effects, year fixed effects, and the state-level characteristics listed in Appendix Table 2. Standard errors are corrected for clustering at the state level. To obtain the interaction-weighted estimates, we ran a separate regression for each mandatory seatbelt law indicator, defining the counterfactual as states never treated by the specific law in question.

Appendix

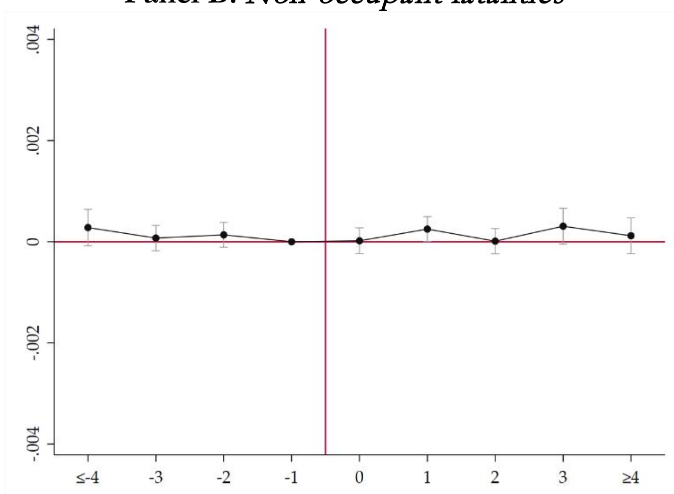
For Online Publication

Appendix Figure 1. Secondary Seatbelt Laws and Traffic Fatalities, 1983-2019: TWFE Event-Study Estimates

Panel A. *Occupant fatalities*



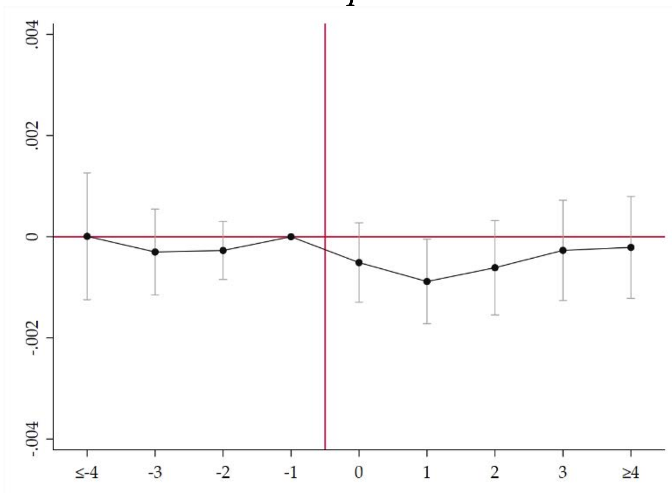
Panel B. *Non-occupant fatalities*



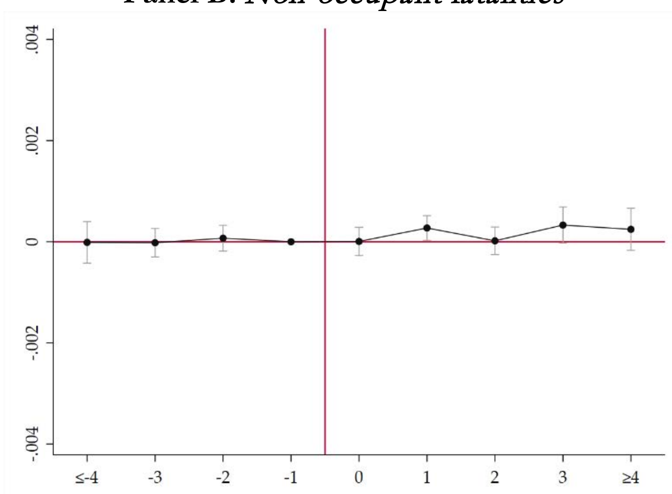
Notes: Based on annual data from the Fatality Analysis Reporting System. Two-way fixed effects estimates (and their 95% confidence intervals) are reported, where the omitted category is one year before treatment. The dependent variable is equal to the number of specified fatalities (occupant or non-occupant) per vehicle miles traveled in state *s* during year *t*. All models control for state fixed effects, year fixed effects, and the state-level characteristics listed in Appendix Table 2. Standard errors are corrected for clustering at the state level.

Appendix Figure 2. Secondary Seatbelt Laws and Traffic Fatalities, 1983-2019: Interaction-Weighted Event-Study Estimates

Panel A. *Occupant fatalities*



Panel B. *Non-occupant fatalities*



Notes: Based on annual data from the Fatality Analysis Reporting System. Interaction-weighted estimates (and their 95% confidence intervals) are reported, where the omitted category is one year before treatment. The dependent variable is equal to the number of specified fatalities (occupant or non-occupant) per vehicle miles traveled in state *s* during year *t*. All models control for state fixed effects, year fixed effects, and the state-level characteristics listed in Appendix Table 2. Standard errors are corrected for clustering at the state level.

Appendix Table 1. Effective Dates of Primary and Secondary Seatbelt Laws, 1983-2019

	Secondary Seatbelt Law	Primary Seatbelt Law
AK	9/12/90	5/1/06
AL	7/1/92	12/10/99
AR	7/15/91	6/30/09
AZ	1/1/91	…
CA	1/1/86	1/1/93
CO	7/1/87	…
CT	…	1/1/86
DC	12/12/85	10/9/97
DE	1/1/92	6/30/03
FL	7/1/86	6/30/09
GA	9/1/88	7/1/96
HI	…	12/16/85
IA	…	7/1/86
ID	7/1/86	…
IL	7/1/85	7/3/03
IN	7/1/87	7/1/98
KS	7/1/86	6/10/10
KY	7/1/94	7/20/06
LA	7/1/86	9/1/95
MA	2/1/94	…
MD	7/1/86	10/1/97
ME	12/27/95	9/20/07
MI	7/1/85	4/1/00
MN	8/1/86	6/9/09
MO	9/28/85	…
MS	3/20/90	5/27/06
MT	10/1/87	…
NC	…	10/1/85
ND	7/14/94	…
NE	1/1/93	…
NH	…	…
NJ	3/1/85	5/1/00
NM	…	1/1/86
NV	7/1/87	…
NY	…	12/1/84
OH	5/6/86	…
OK	2/1/87	11/1/97
OR	…	12/7/90
PA	11/23/87	…
RI	7/1/91	6/30/11
SC	7/1/89	12/9/05
SD	1/1/95	…

Appendix Table 1. Effective Dates of Primary and Secondary Seatbelt Laws, 1983-2019 (continued)

	Secondary Seatbelt Law	Primary Seatbelt Law
TN	4/21/86	7/1/04
TX	…	9/1/85
UT	4/28/86	5/12/15
VA	1/1/88	…
VT	1/1/94	…
WA	6/11/86	7/1/02
WI	12/1/87	6/30/09
WV	9/1/93	7/1/13
WY	6/8/89	…

Notes: Effective dates on mandatory seatbelt laws come from the Insurance Information Institute.

Appendix Table 2. Descriptive Statistics

	Mean (SD) 1983-1997	Mean (SD) 1983-2019	Description	Source
Occupant fatalities	0.018 (0.006)	0.014 (0.006)	Occupant fatalities per vehicle miles traveled	Fatality Analysis Reporting System
Non-occupant fatalities	0.003 (0.002)	0.002 (0.001)	Non-occupant fatalities per vehicle miles traveled	Fatality Analysis Reporting System
Independent variables				
SSL	0.13 (0.34)	0.37 (0.48)	= 1 if state has a secondary seatbelt law or has a primary seatbelt law that was preceded by a secondary seatbelt law, = 0 otherwise	Insurance Information Institute
PSL	0.51 (0.50)	0.70 (0.46)	= 1 if state has a primary seatbelt law that was not preceded by a secondary seatbelt law, = 0 otherwise	Insurance Information Institute
SSL to PSL	0.02 (0.14)	0.23 (0.42)	= 1 if state has a primary seatbelt law that was preceded by a secondary seatbelt law, = 0 otherwise	Insurance Information Institute
% Black	0.11 (0.12)	0.11 (0.12)	Percent of the state population that is Black	U.S. Census
% Hispanic	0.05 (0.07)	0.08 (0.09)	Percent of the state population that is Hispanic	U.S. Census
Mean age	34.5 (1.70)	36.2 (2.24)	Mean age of the state population	U.S. Census
Median income	18,586 (4,829)	31,193 (13,563)	State median income (in current dollars)	U.S. Census
Unemployment	0.06 (0.02)	0.06 (0.02)	State unemployment rate	Bureau of Labor Statistics
Violent crime	2.05 (1.78)	1.70 (1.39)	State violent crimes per 1,000 population	FBI's Uniform Crime Reports
Property crime	44.5 (12.1)	36.3 (12.5)	State property crimes per 1,000 population	FBI's Uniform Crime Reports
Rural traffic density	0.64 (0.85)	0.70 (1.00)	Registered vehicles per unit length of rural roads in miles	*Highway Statistics*, annual publication by U.S. DOT
Urban traffic density	1.82 (0.49)	1.48 (0.53)	Registered vehicles per unit length of urban roads in miles	*Highway Statistics*, annual publication by U.S. DOT
Rural VMT	16,540 (12,563)	18,458 (14,296)	Vehicle miles traveled on rural roads	*Highway Statistics*, annual publication by U.S. DOT
Urban VMT	24,884 (33,184)	33,008 (43,171)	Vehicle miles traveled on urban roads	*Highway Statistics*, annual publication by U.S. DOT
Fuel tax	16.3 (4.96)	19.9 (6.79)	Fuel tax (in current cents)	*Highway Statistics*, annual publication by U.S. DOT
65 MPH limit	0.54 (0.50)	0.44 (0.50)	= 1 if state has a top speed limit of 65 miles per hour, = 0 otherwise	Insurance Information Institute
70+ MPH limit	0.05 (0.22)	0.37 (0.48)	= 1 if state has a top speed limit of 70 miles per hour or higher, = 0 otherwise	Insurance Information Institute
BAC 0.08	0.12 (0.32)	0.57 (0.50)	= 1 if state has a 0.08 blood alcohol content law, = 0 otherwise	Insurance Information Institute
MLDA 21	0.87 (0.34)	0.95 (0.23)	= 1 if state has a minimum legal drinking age of 21, = 0 otherwise	Insurance Information Institute

Notes: Means are unweighted and standard deviations are in parentheses.

Appendix Table 3. Seatbelt Laws and Traffic Fatalities: Replication and Extension of Cohen and Einav (2003) – Natural Log of the Dependent Variable

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	TWFE estimates reported in Table 5 of Cohen and Einav (2003)		Replication of Cohen and Einav (2003) + SEs clustered at the state level		Columns (3) and (4) + extending sample period through 2019		Columns (5) and (6) + interaction-weighted estimator from Sun and Abraham (2021)	
	ln(*Occupant Fatalities*)	ln(*Non-occupant fatalities*)	ln(*Occupant Fatalities*)	ln(*Non-occupant fatalities*)	ln(*Occupant Fatalities*)	ln(*Non-occupant fatalities*)	ln(*Occupant Fatalities*)	ln(*Non-occupant fatalities*)
SSL	-0.042***	0.0005	-0.0358***	-0.0112	-0.0194	0.0008	-0.0107	0.0524*
	(0.013)	(0.032)	(0.0128)	(0.0028)	(0.0294)	(0.0326)	(0.0235)	(0.0298)
PSL	-0.061***	0.084**	-0.0538**	0.0985*	-0.0713**	0.0786	-0.0612**	0.0689
	(0.022)	(0.042)	(0.0248)	(0.0539)	(0.0294)	(0.0581)	(0.0308)	(0.0642)
SSL to PSL	-0.030	0.086	-0.0358	0.1093	-0.0255	0.0200	0.0550	0.1380
	(0.024)	(0.063)	(0.0286)	(0.0685)	(0.0187)	(0.0213)	(0.0582)	(0.0816)
Pre-*SSL* mean	Not reported	Not reported	0.0212	0.0035	0.0212	0.0035	0.0212	0.0035
Pre-*PSL* mean	Not reported	Not reported	0.0221	0.0046	0.0221	0.0046	0.0221	0.0046
Pre-*SSL to PSL* mean	Not reported	Not reported	0.0186	0.0033	0.0173	0.0028	0.0173	0.0028
Years	1983-1997	1983-1997	1983-1997	1983-1997	1983-2019	1983-2019	1983-2019	1983-2019
N	765	765	765	765	1,887	1,887	1,887	1,887

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from the Fatality Analysis Reporting System. Two-way fixed effects (columns (1)-(6)) and interaction-weighted (columns (7)-(8)) estimates are reported. The dependent variable is equal to the natural log of the number of specified fatalities (occupant or non-occupant) per vehicle miles traveled in state *s* during year *t*. All models control for state fixed effects, year fixed effects, and the state-level characteristics listed in Appendix Table 2. Standard errors are corrected for clustering at the state level. To obtain the interaction-weighted estimates, we ran a separate regression for each mandatory seatbelt law indicator, defining the counterfactual as states never treated by the specific law in question.

Appendix Table 4. Seatbelt Laws and Traffic Fatalities: Replication and Extension of Cohen and Einav (2003) – Estimates Weighted by State Population

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Replication of Cohen and Einav (2003) + weighted by state population		Columns (1) and (2) + SEs clustered at the state level		Columns (3) and (4) + extending sample period through 2019		Columns (5) and (6) + interaction-weighted estimator from Sun and Abraham (2021)	
	Occupant fatalities	*Non-occupant fatalities*	*Occupant fatalities*	*Non-occupant fatalities*	*Occupant fatalities*	*Non-occupant fatalities*	*Occupant fatalities*	*Non-occupant fatalities*
SSL	-0.0007***	0.0002*	-0.0007***	0.0002	-0.0009***	0.0001	-0.0005*	0.0003*
	(0.0002)	(0.0001)	(0.0003)	(0.0002)	(0.0003)	(0.0001)	(0.0003)	(0.0002)
PSL	-0.0015***	-0.0001	-0.0015**	-0.0001	-0.0021***	-0.0001	-0.0018***	-0.0003
	(0.0003)	(0.0001)	(0.0004)	(0.0002)	(0.0004)	(0.0003)	(0.0004)	(0.0002)
SSL to PSL	-0.0002	0.0005***	-0.0002	0.0005***	-0.0006**	0.0001	-0.0004	0.0003**
	(0.0003)	(0.0001)	(0.0003)	(0.0001)	(0.0002)	(0.0001)	(0.0006)	(0.0001)
Pre-*SSL* mean	Not reported	Not reported	0.0207	0.0039	0.0207	0.0039	0.0207	0.0039
Pre-*PSL* mean	Not reported	Not reported	0.0211	0.0052	0.0211	0.0052	0.0211	0.0052
Pre-*SSL to PSL* mean	Not reported	Not reported	0.0179	0.0036	0.0168	0.0032	0.0168	0.0032
Years	1983-1997	1983-1997	1983-1997	1983-1997	1983-2019	1983-2019	1983-2019	1983-2019
N	765	765	765	765	1,887	1,887	1,887	1,887

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from the Fatality Analysis Reporting System. Two-way fixed effects (columns (1)-(6)) and interaction-weighted (columns (7)-(8)) estimates are reported. The dependent variable is equal to the number of specified fatalities (occupant or non-occupant) per vehicle miles traveled in state *s* during year *t*. All models control for state fixed effects, year fixed effects, and the state-level characteristics listed in Appendix Table 2. Estimates are weighted by state population and standard errors are corrected for clustering at the state level. To obtain the interaction-weighted estimates, we ran a separate regression for each mandatory seatbelt law indicator, defining the counterfactual as states never treated by the specific law in question.

Appendix Table 5. Sensitivity of Interaction-Weighted Estimates to Alternative Control Groups + Estimates from Callaway and Sant'Anna (2021) Procedure

	(1)	(2)	(3)	(4)	(5)
	Interaction-weighted estimator from Sun and Abraham (2021)			Callaway and Sant'Anna (2021) estimator	
	Occupant Fatalities	*Occupant Fatalities*	*Occupant Fatalities*	*Occupant Fatalities*	*Occupant Fatalities*
SSL	-0.0004	-0.0003	-0.0004	-0.0006	-0.0006
	(0.0004)	(0.0004)	(0.0003)	(0.0005)	(0.0005)
PSL	-0.0009	-0.0010*	-0.0009*	-0.0017**	-0.0017**
	(0.0006)	(0.0006)	(0.0005)	(0.0007)	(0.0007)
SSL to PSL	-0.0002	-0.0003	-0.0002	-0.0004	-0.0001
	(0.0004)	(0.0005)	(0.0004)	(0.0009)	(0.0008)
Pre-*SSL* mean	0.0220	0.0216	0.0213	0.0212	0.0211
Pre-*PSL* mean	0.0221	0.0221	0.0221	0.0221	0.0221
Pre-*SSL to PSL* mean	0.0183	0.0176	0.0170	0.0186	0.0173
Years	1983-1990	1983-1992	1983-1996	1983-1997	1983-2019
N	678	722	763	765	1,887

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from the Fatality Analysis Reporting System. Interaction-weighted estimates (columns (1)-(3)) and estimates from the procedure developed by Callaway and Sant'Anna (2021) (columns (4)-(5)) are reported. The dependent variable is equal to the number of occupant fatalities per vehicle miles traveled in state *s* during year *t*. To obtain the interaction-weighted and Callaway and Sant'Anna (2021) estimates, we ran a separate model for each mandatory seatbelt law indicator. The interaction-weighted models control for state fixed effects, year fixed effects, and the state-level characteristics listed in Appendix Table 2, and standard errors are corrected for clustering at the state level. The Callaway and Sant'Anna (2021) models control for the alternative mandatory seatbelt law indicators, and bootstrap-based standard errors are reported.

Appendix Table 6. Seatbelt Usage and Traffic Fatalities: Replication and Extension of Cohen and Einav (2003)

	(1)	(2)	(3)	(4)	(5)	(6)
	Instrumental variable estimates reported in Table 2 of Cohen and Einav (2003)		Replication of Cohen and Einav (2003) + SEs clustered at the state level		Columns (3) and (4) + extending sample period through 2019	
	Occupant Fatalities	ln(*Occupant fatalities*)	*Occupant Fatalities*	ln(*Occupant Fatalities*)	*Occupant Fatalities*	ln(*Occupant Fatalities*)
Seatbelt usage	-0.005***	…	-0.0062**	…	-0.0063***	…
	(0.002)		(0.0030)		(0.0022)	
ln(*Seatbelt usage*)	…	-0.133***	…	-0.2020**	…	-0.2266**
		(0.047)		(0.0930)		(0.0911)
F-test of instrument	Not reported	Not reported	31.98	21.23	52.60	55.78
Dependent variable mean	Not reported	Not reported	0.0211	0.0211	0.0202	0.0202
Years	1983-1997	1983-1997	1983-1997	1983-1997	1983-2019	1983-2019
N	556	556	420	420	1,530	1,530

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from the Fatality Analysis Reporting System. Two-stage least squares estimates are reported, where the mandatory seatbelt indicators (*SSL*, *PSL*, and *SSL to PSL*) are used as instruments. In odd-numbered columns, the dependent variable is equal to the number of occupant fatalities per vehicle miles traveled in state *s* during year *t*. In even-numbered columns, the dependent variable is equal to the natural log of the number of occupant fatalities per vehicle miles traveled in state *s* during year *t*. All models control for state fixed effects, year fixed effects, and the state-level characteristics listed in Appendix Table 2. Standard errors are corrected for clustering at the state level. The difference in sample sizes between columns (1)-(2) and columns (3)-(4) is due to the fact that were we unable to collect data on seatbelt usage for as many state-years as were available to Cohen and Einav (2003).