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REPLICATION SECTION

SUCCESSFUL SCIENTIFIC REPLICATION AND EXTENSION OF LEVITT (2008): CHILD SEATS ARE STILL NO SAFER THAN SEAT BELTS

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SUMMARY

Using US fatality data from 1975 to 2003, Levitt (Evidence that seat belts are as effective as child safety seats in preventing death for children aged two and up, *Review of Economics and Statistics* 2008; **90**(1): 158–163) shows that child safety seats do not significantly reduce fatalities for children aged 2–6 years as compared to standard seat belts. Although we were unable to gain access to the original programs and dataset used, we were able to replicate Levitt's (2008) findings almost exactly. We extend Levitt (2008) by showing that the findings also hold for the years 2004–2011 despite changing driver characteristics and restraint use patterns. We fail to find evidence that SUVs provide additional safety for children. Copyright © 2015 John Wiley & Sons, Ltd.

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1. INTRODUCTION

In the USA, as well as in over 90 countries worldwide, traffic safety regulations require use of specific, approved child safety seats for children in automobiles (World Health Organization, 2013). Currently, all US states mandate the use of child safety seats. Forty-three states require the use of child safety seats until at least age 4 years, but statutory age and weight regulations have increased significantly over time. For first-time offenders, the variation in fines for no use ranges from $20 (West Virginia) up to $500 (Nevada), with a mass point around $100 (Insurance Institute for Highway Safety, 2013).

Despite the prevalence and increasing stringency of these laws, there is evidence that child seats may not be any more effective than traditional seat belts at preventing death and severe injury. Using 1975–2003

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data from the US Fatality Analysis Reporting System (FARS), Levitt (2008) shows empirically that among children aged 2–6 years the use of child safety seats does not significantly reduce the probability of a fatality in accidents relative to traditional seat belts.[1] This finding casts serious doubts on the effectiveness of child safety seats, despite strong support for the regulation among the public and health scientists (cf. Zaza *et al.*, 2001). If child safety seats do not provide any safety premium over standard seat belts, then laws that require citizens to buy and use child seats, along with the costs of their enforcement, represent a costly and welfare-decreasing state regulation. It is worthwhile to note that, to date, no (economic) study has seriously challenged Levitt's (2008) findings.

Because of the high practical relevance of this question, we endeavor to replicate Levitt's (2008) original findings and to test whether Levitt's (2008) findings also apply to a more recent time period, from 2004 to 2011. The latter contribution is important since the last decade has seen potential safety improvements generated by manufacturer improvements and trends in traffic safety and road conditions. We provide an extended discussion of how results from the contemporary era are affected by such changing conditions.

We additionally update and enrich Levitt's (2008) analysis by investigating the impact on restraint effectiveness of two specific traffic safety developments: first, the SUV 'arms race'—which makes roads less safe since accidents involving passenger cars and SUVs have an increased fatality probability (White, 2004; Daly *et al.*, 2006; Small and Van Dender, 2007; Li, 2012; Klier and Linn, 2012; Busse *et al.*, 2013); and second, the misuse of child safety seats (Howland *et al.*, 1965; Bull *et al.*, 1988). We investigate how these two traffic phenomena—the SUV arms race and improper use of child seats—mitigate or strengthen Levitt's (2008) findings on the effectiveness of child safety seat versus traditional seat belt use.

2. SCIENTIFIC REPLICATION AND EXTENSION OF LEVITT (2008)

2.1. Replication of Levitt (2008): Data and Methods Used

Levitt (2008) uses the US FARS data from 1975 to 2003. The dataset includes the universe of all accidents in which at least one person died. Moreover, it includes information on the type of restraint used by each vehicle occupant involved in a fatal crash. In conducting this replication, we followed descriptions and explanations in Levitt (2005, 2008). After accessing the FARS data, we followed the description of how the author restricted the data as closely as possible.[2] Owing to the number of restrictions imposed, we were unable to perfectly replicate the working dataset. While our total sample has 38,456 observations, his has only 37,635.

As explained in Levitt (2008), the econometric approach employed regresses a binary indicator of whether a child died in a crash or not on the main variables of interest. The main variables of interest consist of a set of dummies for restraint use: (i) no restraint; (ii) child safety seat; (iii) lap-only belt; and (iv) lap and shoulder belt. In addition, a rich set of vehicle and driver characteristics are used as controls. All models are estimated as linear probability models.

This simple regression intends to explain the statistical relationship between the type of restraint used and the probability that a child dies in a fatal car accident. The accidents included in the FARS

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[1] Doyle and Levitt (2010) show that this result also holds for serious injuries. However, they find that child safety seats lead to a significant 25% reduction in light injuries among 2- to 6-year-old children.

[2] Levitt (2008) drops crashes in which the only fatalities were pedestrians, motorcyclists, or occupants of nonstandard vehicles. He limits the analysis to occupants of automobiles, minivans and SUVs with model years older than 1969, and discards observations with missing values on relevant variables and cases in which the occupant did not sit in the first three rows of the vehicle. Finally, he restricts the sample to children between ages 2 and 6 years.

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data, however, include only fatal crashes and do not provide a random sample of American vehicles and occupants. Since restraint use may affect the probability of dying in a crash, the probability of being included in the FARS data is not independent of restraint use. Levitt (2008) adopts the Levitt and Porter (2001) approach to correct for this sample selection issue. The simple idea is to restrict the sample to two-car crashes where a death occurred in the *second* vehicle involved. The sample selection issue is then resolved under the assumption that restraint use in vehicle A does not affect the probability that an occupant dies in vehicle B, given both vehicles are involved in an accident.

Columns (1)–(4) of Table I show the exact replication of Table III in Levitt (2008). However, in the interest of space, we only show results from the fully controlled model and the specification without any controls (columns (1), (3), (4), and (6) in the Levitt paper). Columns (1) and (2) in Table I use the full sample without the sample selection correction, while columns (3) and (4) focus on the subset of two-car crashes with a death in the other car. Columns (1) and (3) regress the child death probability on the set of restraint use dummies alone, while columns (2) and (4) additionally control for a wide range of background information as indicated in the rows of Table I. In all models, the reference category is *no restraint*, such that the estimates for each restraint type indicate the change in death probability relative to being unrestrained. Given a child is unrestrained and involved in an accident with a fatality, the baseline probability that the child dies is 27%.

The point estimates for all coefficients displayed in the first two columns of our Table I are almost identical to Levitt's (2008) coefficients. For example, in column (1) of his table, Levitt (2008) reports a point estimate for *child seat* of −0.112, which is significant at the 1% level. Our equivalent estimate in column (1) of Table I shows a coefficient −0.1144, also significant at the 1% level. Table A1 in the online Appendix (supporting information) formally tests the statistical difference between our and Levitt's (2008) restraint use coefficients. The differences are negligible.

One can summarize the results displayed in the first two columns of Table I as follows: (i) using a child safety seat, a lap and shoulder belt, or a just a lap belt reduces the likelihood that a child dies in a fatal accident by about 10 ppt or 30% as compared to being unrestrained; (ii) controlling for a wide range of background information barely changes the point estimates; and (iii) the differences between our point estimates and Levitt's (2008) are very small and not statistically significant. Our replication results confirm Levitt's main finding: child safety seats provide no additional safety benefit as compared to shoulder and lap or lap-only belts. Indeed, formally comparing the *lap and shoulder belt* to the *child seat* coefficient in an additional robustness check suggests that seat belts reduce the probability of death by 2.7 ppt relative to child safety seats. With 95% statistical confidence, we are able to rule out any significant effectiveness differences in favor of child safety seats.[3]

The models in columns (3) and (4) of Table I use a subset of observations to correct for sample selection and use about 2000 fewer observations than Levitt's (2008) comparable sample.[4] Consequently, the point estimates differ slightly, but the main findings are again very robust (see Table A1 for formal comparisons): use of any restraint type reduces the probability that a child dies in a severe accident, where an occupant dies in the other car, by about 5 ppt on a 7% average unrestrained fatality rate—about a 60% reduction. Any statistically significant differences between restraint type coefficients disappear when our analysis is limited to the selection corrected sample.

[3] This additional check uses child safety seats as the base category; the resulting 95% confidence interval of the coefficient estimate on lap and shoulder belts is (−0.0289, −0.0004), suggesting that any significant differences are in favor of seat belts.

[4] Levitt (2005) writes that 'for the sample selection correction, we created a dummy variable equal to one if someone died in another vehicle involved in the crash'. This implies that all observations in the selection-corrected sample should derive from crashes with at least two vehicles involved. However, in Levitt's (2008) results, a coefficient estimate is reported for the *one-car crash* variable. We followed Levitt (2005) in defining the selection-corrected sample and therefore have no one-car crash victims included. The deviation in sizes between Levitt (2008) and our samples is likely due to the extra inclusion of one-car crash victims in Levitt's sample.

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Table I. Replication and extension of Levitt (2008), Table III (columns 1, 3, 4 and 6): impact of child restraints on probability of fatality

	Dependent variable = 1 if fatal injury, 0 otherwise							
	Levitt replication: 1975–2003				Levitt extension: 1975-2011			
	Without sample Selection correction		With sample Selection correction		Without sample Selection correction		With sample Selection correction	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Child seat	−0.1168***	−0.1144***	−0.0462***	−0.0458***	−0.1168***	−0.1153***	−0.0462***	−0.0473***
	(0.0053)	(0.0068)	(0.0055)	(0.0076)	(0.0053)	(0.0066)	(0.0055)	(0.0075)
Lap and shoulder seat	−0.1046***	−0.1290***	−0.0470***	−0.0524***	−0.1046***	−0.1315***	−0.0470***	−0.0524***
	(0.0060)	(0.0072)	(0.0058)	(0.0080)	(0.0060)	(0.0071)	(0.0058)	(0.0079)
Lap-only belt	−0.1245***	−0.1080***	−0.0512***	−0.0480***	−0.1245***	−0.1115***	−0.0512***	−0.0476***
	(0.0061)	(0.0068)	(0.0058)	(0.0073)	(0.0061)	(0.0067)	(0.0058)	(0.0073)
Child seat * post 2003	—	—	—	—	−0.0818***	−0.0456***	−0.0646**	−0.0439
					(0.0131)	(0.0133)	(0.0249)	(0.0237)
Lap and shoulder belt * post 2003	—	—	—	—	−0.0936***	−0.0404**	−0.0559*	−0.0347
					(0.0145)	(0.0146)	(0.0254)	(0.0243)
Lap belt * post 2003	—	—	—	—	−0.0495*	−0.0158	−0.0550	−0.0372
					(0.0193)	(0.0192)	(0.0268)*	(0.0255)
Post 2003	—	—	—	—	0.0662***	0.1148***	0.0569*	0.0293
					(0.0113)	(0.0266)	(0.0244)	(0.0451)
Controls								
Position of child in car, gender, age of child, driver belted, car, model year, vehicle weight, type of crash; other controls in Levitt (2008); year fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.0195	0.0810	0.0130	0.0496	0.0248	0.0824	0.0165	0.0524
Any sig. diff. between child seat and belt coeff.?	No	No	No	No	No	Yes	No	No
N	38,456	38,456	10,330	10,330	48,203	48,203	13,550	13,550

Note: $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$; data from the Fatality Analysis Reporting System (FARS) for the years 1975–2011. Values in the table show the change in probability of dying in the crash associated with each restraint type, relative to being unrestrained. Results in columns (1), (2), (5) and (6) are obtained from analyses using the sample of all 2- to 6-year-olds involved in a fatal crash; results in columns (3), (4), (7) and (8) are obtained from analyses using the sample of all 2- to 6-year-olds involved in a two-car fatal crash where someone died in the other car. 'Other controls in Levitt (2008)' include the difference in weight of the cars, indicators for missing vehicle weight, of whether the driver had any major violations, of whether the speed limit on the road was less than or equal to 55 mph, of whether the crash occurred on a rural road, and of whether the crash occurred on a weekend, at night (8 pm to midnight), in the early morning (1–5 am). The position of child in car variable indicates where the child was seated in the car relative to the middle seat in the back row. The child age categories are defined relative to 2-year-olds. All reported regressions are linear probability models. Standard errors are clustered at the vehicle level, and are reported in parentheses. We conduct F-tests to compare each seat belt coefficient estimate to the child seat coefficient; in columns (5)–(8), we conduct separate F-tests for the pre- and post-2003 periods. If any F-test revealed a significant difference, we indicate this with a 'Yes'.

2.2. Extension of Levitt (2008): Do the Results Hold Up in the 'Arms Race' Era 2004–2011?

Columns (5)–(8) of Table I extend Levitt's (2008) analysis by adding data from the years 2004–2011. We add a *post2003* dummy to the analysis and interact it with all restraint use variables of interest to identify whether restrain effectiveness has changed in the post-2003 period. The results reveal the following: (i) in the modern era, relative to unrestrained children, children in safety belts and child seats appear even less likely to die, i.e. restraint use in general seems to have become more effective; (ii) in the post-2003 period, correction for observables does matter. When controlling for a wide range of background characteristics, the coefficients significantly decrease in size. Still, the effects are significant and large, given that the mean fatality rate in the modern era for unrestrained children is about 33%: for a 2- to 6-year-old child, both traditional seat belts and child safety seats reduce the probability of dying in a fatal accident by about 50% relative to being unrestrained; (iii) the selection-corrected models in columns (7) and (8), with just 13,550 observations, lack statistical power when differentiating between the pre- and post-2003 time periods. However, when we partition the data and estimate models on the 2004–2011 selection-corrected sample we find that restraints reduce the likelihood of dying in a crash by about 70%[5]; and (iv) the main finding and conclusion of Levitt (2008) also hold in more recent years under changing traffic conditions: when it comes to preventing fatalities, child safety seats are *not* more effective than simple lap and shoulder restraints.[6]

3. RESTRAINT USE AND EFFECTIVENESS IN THE MODERN ERA

3.1. Increased Effectiveness of Restraint Use: An Artifact of a More Negatively Selected Group of Parents Who do not Restraint their Kids?

The results in Table I beg the question: are restraints becoming more effective with time?[7] Fig. 1(a) plots the rates of restraint use over time for children between ages 2 and 6 years, given they were involved in a fatal accident. The most striking observation is the strong, almost linear, decline in the share of children who are not restrained. In 1980 almost 100% of all 2- to 6-year-olds in the sample were unrestrained. This proportion had dropped to about 50% by the mid 1990s and to below 20% by 2010. It is obvious that, in the modern era, the group of children who remain unrestrained are a select sample and that their restraint use patterns are driven by a select group of parents or guardians.[8] If the marginal who does not restrain their child is arguably less safety conscious than the average restraint user, average driver quality among non-restraint users is decreasing over time.

Figure A1 in the online Appendix provides evidence that the characteristics of drivers using different child restraint technologies is changing over time. For four characteristics, the figure plots the proportion of drivers using each restraint type for the child in their car with the given characteristic. The figure shows that, over time, drivers who do not restrain their children have become younger, more likely to

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[5] The coefficient estimates for the selection-corrected models estimated on the 2004–2011 data only are −0.0828*** for *child seat* and −0.0759*** for *lap and shoulder belt*. The coefficient estimates are not significantly different from one another.

[6] The *F*-tests reported in Table I compare each seat belt coefficient estimate to the child seat coefficient; in columns (5)–(8), we conduct separate *F*-tests for the pre- and post-2003 periods. The only statistical difference we identify is in regression (6). Lap and shoulder belts appear significantly *more* effective than child seats in the pre-2003 period when covariates are considered. In a robustness check, we also interacted an indicator of whether the child sat in the first row with all types of restraint use (results upon request). The findings show that sitting in the front row is a lot more dangerous, but that seat belts and child safety seats mitigate the risk about equally well.

[7] Beyond the discussion here, we also estimated all our models by interacting all covariates with the post-2003 indicator, using a series of different data cut-offs to partition the data, and including state-specific linear time trends, none of which significantly changed our results.

[8] Among the selection corrected sample, only about 40% of children were unrestrained in the mid 1980s. The fraction of children who were unrestrained dropped to 20% in the mid 1990s, and to only about 5% by 2010.

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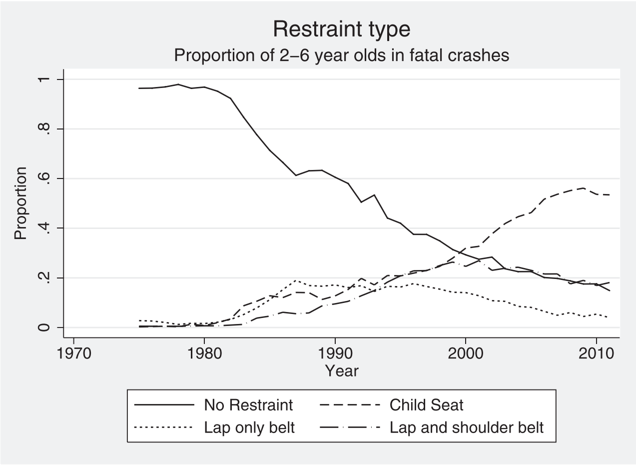
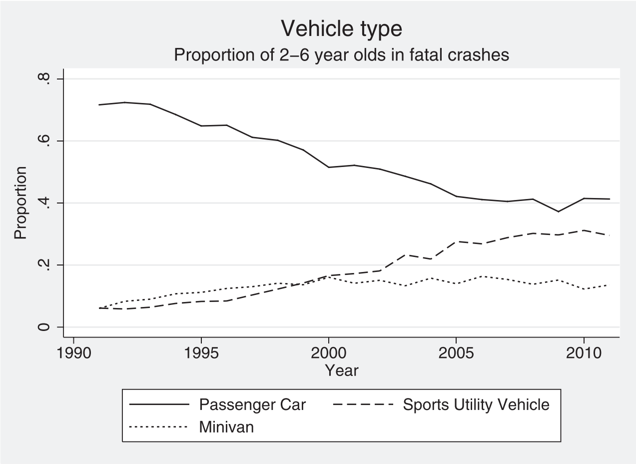


(a)



(b)

Figure 1. Development of restraint use (1975–2011) and vehicle type (1992–2011). Sources: FARS data, own illustration

have consumed alcohol or have a previous major violation, and more likely to be unrestrained themselves than the average driver in the sample. The figure reinforces the hypothesis outlined above and suggests that the quality of drivers who do not restrain a child has decreased over time—a result that may explain the finding of increased restraint effectiveness after 2003.

3.2. Restraint Use Development: Implications for Child Safety Seat versus Seat Belt Effectiveness

Figure 1(a) also reveals increased child safety seat use relative to seat belt use in the modern era. If the divergent use patterns are related to unobserved determinants of driver quality, two potential sources of biases could affect our results. First, child safety seat users would be less likely than seat belt users to be included in the FARS fatality sample. However, this source of bias is addressed by use of the Levitt

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and Porter (2001) correction. Second, if the driver quality among the sample of child safety seat users improved relative to seat belt users, child safety seats would appear to increase in effectiveness relative to seat belts in more recent years.

Figure A1 helps dispel this concern. With the exception of age, the driver characteristic trends among child safety seat users match the trends among seat belt users quite closely. The *F*-tests reported in Table I that compare the restraint type coefficients to one another do not reveal significant differences in the selection corrected models. Finally, it is likely that much of the driver age variation in seat belt use versus child seat use is due to variation in state-level laws regulating the age until which child safety seat use is mandatory. Indeed, the average age of children in the sample who are restrained in child seats is about 3 years, while those restrained by traditional seat belts are about 4.5 years old.[9]

3.3. The Role of SUVs and Improper Use in Restraint Effectiveness

Figure 1(b) describes another recent development in road safety conditions: the share of traditional passenger cars versus SUVs on the road. Passenger car use in the sample declined from about 70% in 1980 to about 40% in 2010. Today, about 50% of the sample are riding in minivans or SUVs at the time of a crash. One observes a particularly strong increase in the use of SUVs since the year 2000—a near doubling from 17% to 31%. The increasing prevalence of SUVs involved in crashes leads us to wonder whether the effectiveness of child safety restraint is enhanced or diminished in crashes involving SUVs.

The results in Table II formally show how the interplay between SUV and restraint use affects safety in the 1991–2011 period. Columns (1) and (3) show how restraint type effectiveness changes when the child is riding in an SUV. Interestingly, we do not find evidence that SUVs use alone reduce the probability that a child dies in a crash—in general and in the selection correction approach in column (3). However, in the naïve model in column (1), there is some evidence that child safety seat use *in combination* with SUV use reduces child fatalities by an additional 4 ppt or 25% beyond child seat use alone, while seat belt use does not appear additionally effective in SUVs.[10] Once selection into the sample of fatalities is corrected for, the child seat safety premium associated with SUV use disappears. In column (3), the coefficient estimates on both the seat belt and child seat interaction terms are relatively small in magnitude, almost identical, and not significantly different from 0. Thus, overall, there is little evidence that SUVs prevent fatalities better than other cars, even with the use of restraints.

Lastly, we make use of an explanatory factor that was included in the survey between 1994 and 2007: *improper* child seat and seat belt use. It is estimated that more than half of child safety seats are improperly used (Children's Safety Network, 2005); improper restraint use has also gained media attention (*New York Times*, 2013). Column (2) of Table II illustrates that the safety gains from using lap and shoulder belts are completely offset by their improper use, such that improper use appears as dangerous as no use. Strikingly, improper child safety seat use appears significantly *less* safe than no restraint. While child safety seat use is associated with a 15 ppt decrease in the probability of death, the effect of improper use completely overwhelms the safety gain, resulting in a net *increase* in death probability of about 14 ppt. On a base fatality rate of about 20%, this amounts to about a 75% increase in the likelihood of death associated with improper use of child seats.

There are two main issues with this naïve regression. First, the question of selection bias is again important. Second, reporting of improper use may be correlated with the probability of death in a crash. It is plausible to assume that safety seat use is significantly more likely to be reported as improper if a

[9] We tried partitioning the sample by age and re-estimating the models to determine whether child seat versus seat belt effectiveness depends on child age. For children who are 2 or 3 years old at the time of the accident, seat belts and child seats appear equally effective in preventing death; for 4-, 5- and 6-year olds, our results (available upon request) suggest that seat belts might be slightly more effective than child seats at preventing death.

[10] For all results presented in Table II, we collapse the lap and shoulder belt category and the lap-only belt category due to the relatively few children using lap-only belts in more recent years.

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Table II. Impact of child restraints, improper use, and use in SUVs on probability of fatality

	Dependent variable = 1 if fatal injury, 0 otherwise			
	Without sample Selection correction		With sample Selection correction	
	(1)	(2)	(3)	(4)
Child seat × SUV	−0.0470** (0.0150)		−0.0226 (0.0276)	
Seat belt × SUV	−0.0162 (0.0157)		−0.0218 (0.0279)	
SUV	0.0105 (0.0136)		0.0251 (0.0275)	
Child seat improperly used		0.3014*** (0.0247)		0.1447** (0.0504)
Seat belt improperly used		0.1522*** (0.0370)		0.1119 (0.0726)
Child seat	−0.1310*** (0.0072)	−0.1566*** (0.0077)	−0.0594*** (0.0100)	−0.0618*** (0.0099)
Seat belt	−0.1441*** (0.0066)	−0.1538*** (0.0071)	−0.0632*** (0.0088)	−0.0594*** (0.0095)
Controls				
Position of child in car, gender, age of driver, driver belted, car, model year, vehicle weight, type of crash; other controls in Levitt (2008); year fixed effects	Yes	Yes	Yes	Yes
R^2	0.0861	0.0980	0.0347	0.0449
N	33,140	25,622	10,497	8,264

Note: $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$ data from the Fatality Analysis Reporting System (FARS) for the years 1991–2011. Values in the table show the change in probability of dying in the crash associated with each restraint type, relative to being unrestrained. Results in columns (1) and (2) are obtained from analyses using the sample of all 2- to 6-year-olds involved in a fatal crash; results in columns (3) and (4) are obtained from analyses using the sample of all 2- to 6-year-olds involved in two-car fatal crash where someone died in the other car. Also see notes to Table I.

child died. In the extreme, if the safety seat use of all children who died were specified as improper, while use among all surviving children was always deemed correct, then child death and improper use would be perfectly correlated. We attempt to address this potential measurement issue by including crash-level fixed effects in the models to control for reporting behavior of the attending police officer (see Table AII in the online Appendix). The identifying variation in the crash fixed-effects models could either stem from multiple children in one car or multiple children in different cars, as long as two children are involved in an accident with a fatality. While the addition of crash fixed effects cause the standard errors of the coefficient estimates to inflate, the coefficient estimates in the selection corrected model are barely changed. If the result was due entirely to reporting bias, we would expect this approach to reduce the estimated magnitudes as long as reporting bias is reduced by looking within crash. However, it is certain that the result herein should be interpreted with caution.

4. DISCUSSION AND CONCLUSION

In this paper, we replicate the results in Levitt (2008) nearly perfectly. According to these findings, child safety seats provide no additional safety advantage over traditional lap and shoulder seat belts. It is important to remember that the current results only apply to fatalities; see Doyle and Levitt (2010) for an analysis of restraint use effectiveness in preventing injury.

We extend Levitt's (2008) analysis and show that the results also hold in the new millennium despite some remarkable developments on American roads. For example, child seat safety use has strictly increased while the prevalence of unrestrained children has strictly decreased. We therefore provide an analysis of changing driver characteristics among differently restrained children, a phenomenon that may account for conflicting findings in past studies of restraint effectiveness (e.g. Elliot *et al.*, 2006).

Further analyses show that any SUV safety premium disappears once selection into a crash is accounted for—an important finding given the commonly held belief that SUVs are safer. For example, a 2005 National Highway Traffic Safety Administration report using the same FARS data found that properly restrained children in SUVs are significantly less likely to die in a fatal crash (Starnes, 2005). This finding is also important from a welfare perspective since passengers in cars involved in a crash with an SUV are significantly more likely to die. If SUVs do not provide additional safety benefits to occupants, and endanger passengers in other car types, their increasing prevalence on American roads is cause for concern (White, 2004; Anderson, 2008; Li, 2012).

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